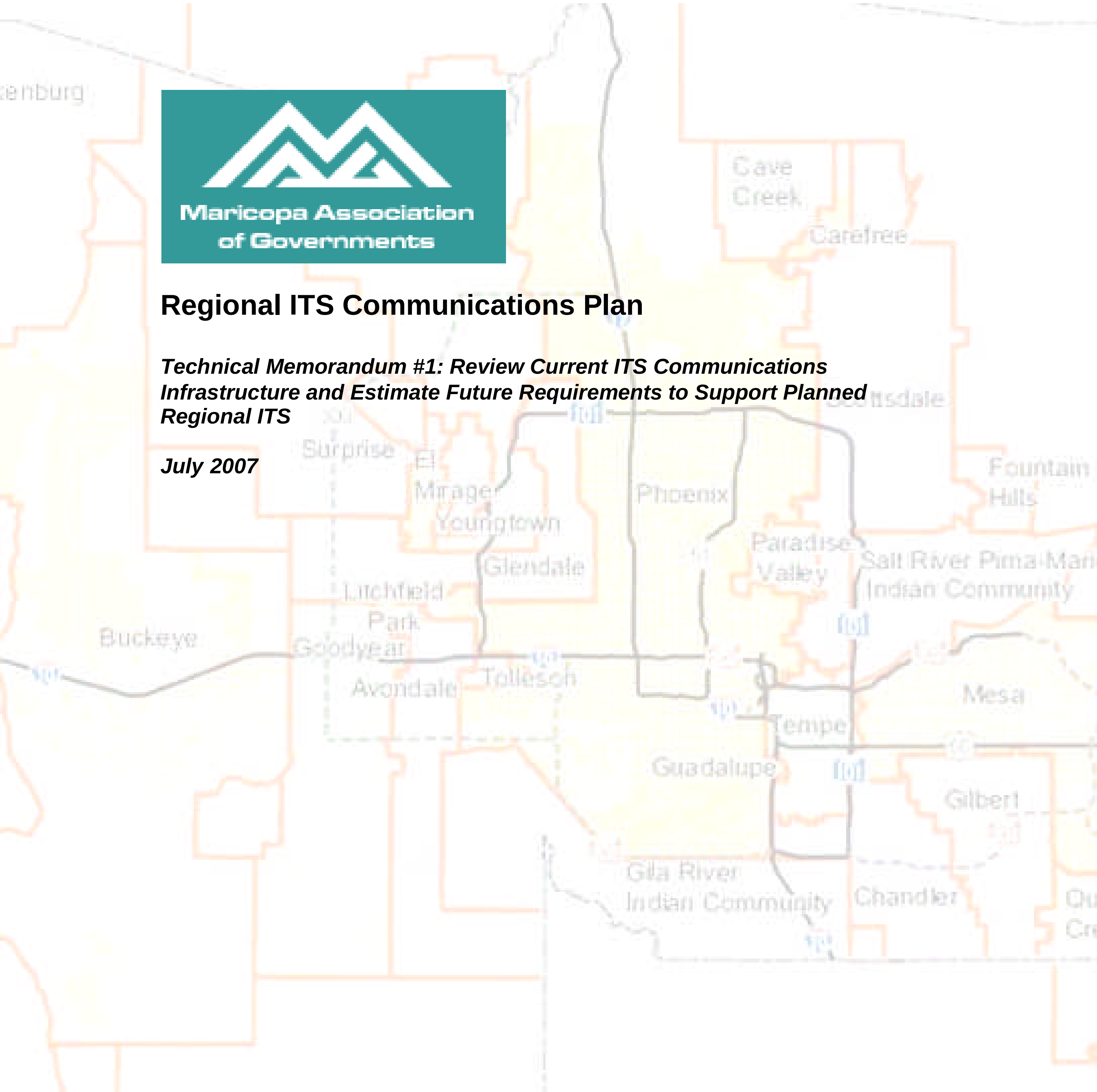
Maricopa Association of Governments

Regional ITS Communications Plan

Technical Memorandum #1: Review Current ITS Communications Infrastructure and Estimate Future Requirements to Support Planned Regional ITS

July 2007



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1.0 Introduction to Initial Conditions and General Requirements

This section reviews the general requirements for ITS communications as well as reviews deployed Infrastructure and centers that are part of the MAG region. This information will be utilized in the development of regional communications topology and supporting architecture.

1.1 Project Overview

This project focuses on the requirements for a regional ITS communications network within the MAG region. The project is not about individual jurisdictional ITS networks, even though they are reviewed in support of determining potential information exchanges to be accomplished over a regional ITS Network. The following assumptions are made:

- Each jurisdiction deploys its own jurisdictional ITS Network. The jurisdictional network is responsible for interconnecting ITS centers within the jurisdiction.

Centers within the jurisdiction include:

- Traffic Management Center (generally for jurisdictions over 20,000 population)
- Emergency Management Center (generally for jurisdictions over 30,000; may use County Sherriff's EMC for smaller jurisdictions)
- Emergency Operations Center (EOC is not a full time, manned center) is activated during an emergency involving many citizens. Most smaller jurisdictions will not have an EMC, and the County EMC will be responsible. The County EMC would be activated if multiple jurisdictions were impacted by a major emergency).
- Public Works Construction and Road Maintenance Vehicle/Tasks Management Center (May not be a formal center for smaller jurisdictions).
- Public Transit Management Center (applicable to jurisdictions having their own public transit system; typically limited to larger cities).

Figure 1.1-1 illustrates the basic architecture. Jurisdictional networks interface with the regional network to establish information exchange. Figure 1.1-2 illustrates the interconnection of regional ITS assets and jurisdictional network into the regional ITS network.

Regional Oriented ITS Service Centers may be Interfaced to the Regional Network. This would include:

- ITS Data Achieving Center (Typically being implemented on a regional basis by the Council of Governments/Association of Governments.

- 511 Traveler Information Center is usually a Regional ITS Asset and is usually a public/private partnership.
- Regional Architecture is migrating towards providing Public Broadcast News Stations with Video Feeds from the 511 Center to provide a single point interconnect for public media.
- Regional and State Emergency Operations Centers may interconnect at the Regional ITS Network Level.
- Regional ITS Networks are being integrated with National Weather Service, sharing regional weather information
- Regional networks are being integrated to form State ITS Networks

Again, this project is limited to the regional network and does not address State ITS Communications Network. However, using open standards and a technology which is modularly expandable to meet state communications data load needs, the regional network should be capable of evolving into a state architecture.

Figure 1.1-1: Basic Regional Architecture Model

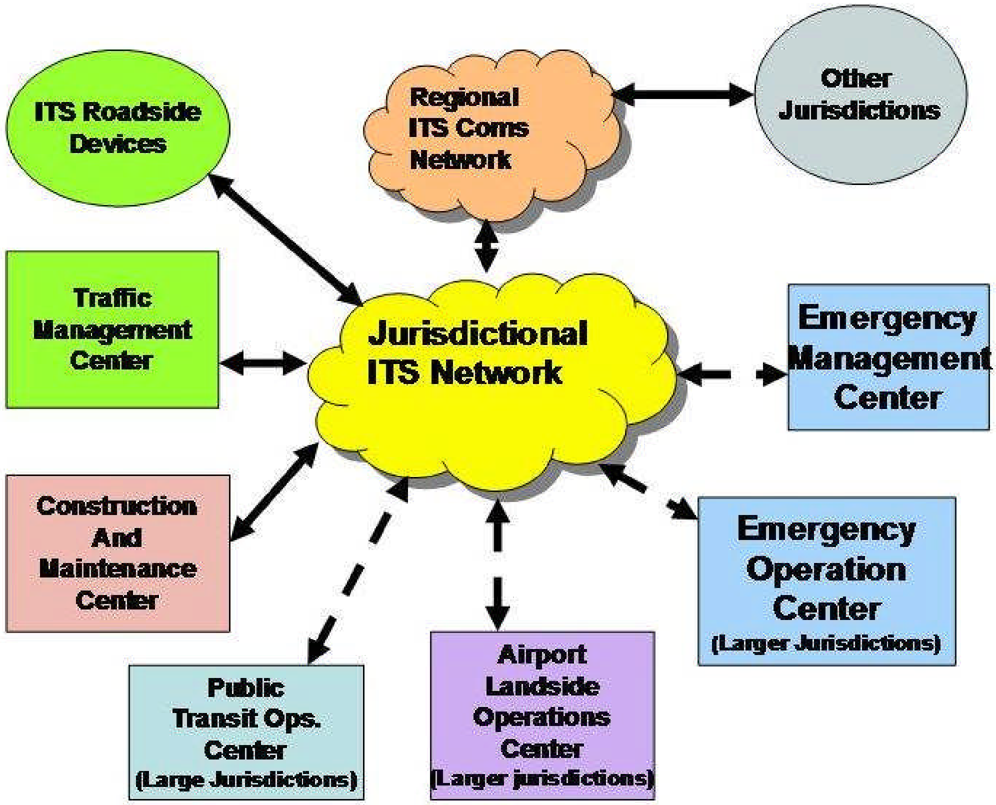
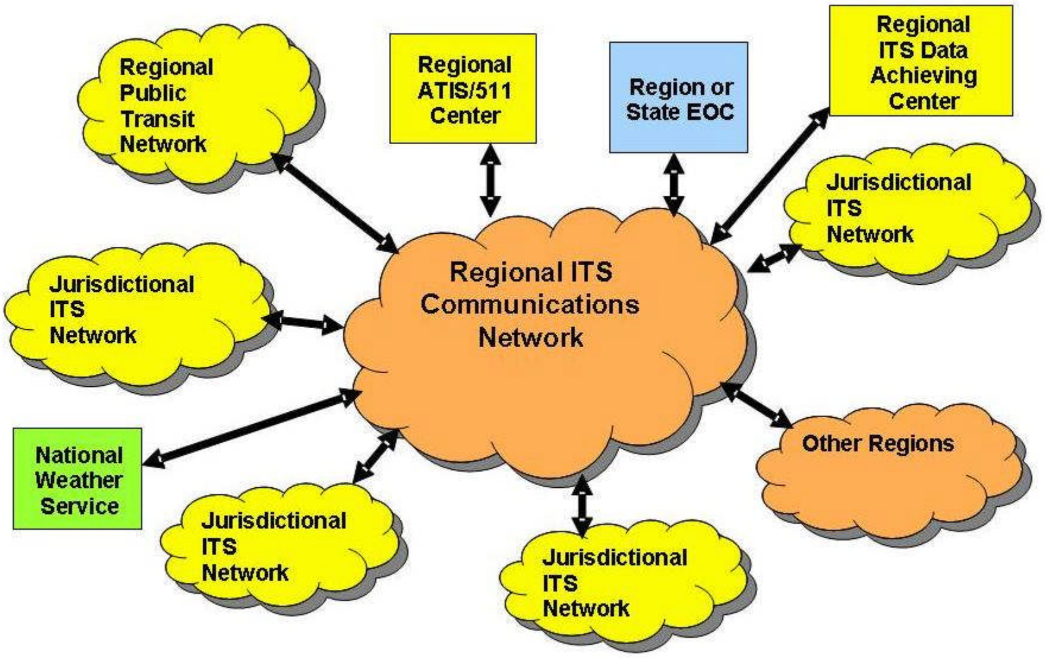


Figure 1.1-2: Jurisdictional Systems Integrate via the Regional ITS Network



What is important for this project is the geographic location of key ITS centers and accessibility to a regional communications network infrastructure.

Some of the general requirements for regional ITS communications network are:

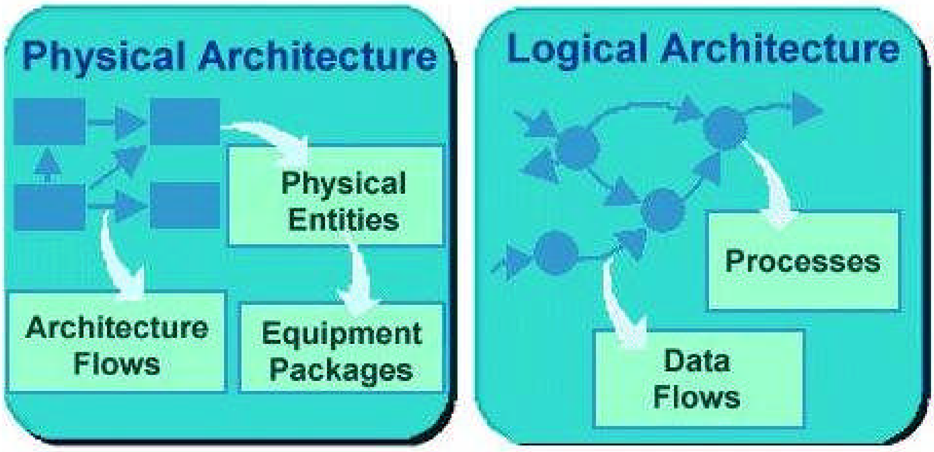
- Meet Data Load Requirements
- Compatible with data, video and voice (all digital)
- High Data reliability
- High Network Availability (99.9% or greater)
- Self-recoverable from a failure
- Capable of Reporting What Failed and Where
- Maintainable and Supportable
- Expandable
- Meet Open Systems Standards
- Uses Modern Technology that is not at the end of its life cycle
- Operates in all weather conditions
- Supports ITS National Standards for Protocols

This study addresses candidate communications technology to meet regional communications needs.

1.2 National ITS Architecture

The National ITS Architecture has evolved since the early 1990s and is now published by the Federal Highway Administration (FHWA) as version 6.0. Figure 1.2-1 illustrates the high level elements defined by the Physical ITS Architecture. Functional information flows and protocol standards for interfaces are included in the National ITS Architecture. The ITS center physical architecture is shown in Figure 1.2-2. Table 1.2-1 summarizes Center and Field elements of the ITS

Figure 1.2-1: ITS High-level Architecture Elements (Ref. FHWA)



ITS Physical Architecture as integrated via optical, copper and wireless communications links supporting communications from field devices to ITS Centers, between ITS Centers, and between infrastructure and vehicles. The current FHWA Vehicle-Infrastructure Integration (VII) initiative is stressing not only infrastructure-vehicle communications but also new developments in vehicle-to-vehicle communications. IEEE and ASTM Digital Short-range Communications (DSRC) standards define the communications standards and protocol for VII. National ITS Architecture includes information flow paths as well as standards for information flow. NEMA/AASHTO National Transportation Communications for ITS Protocol (NTCIP) standards define field to Center communications standards and include Center-to-Center standards. IEEE 1512 standard defines communications between Emergency Management Centers, Traffic management Centers and Public Transit Management Centers. ASTM E2259-03a Standard provides a “Guide for Archiving and Retrieving ITS-Generated Data.” Table 1.2-2 summarizes User Services that are defined as part of the National ITS Architecture. User Services are high-level functional definitions of services performed through ITS selected deployment. (Note: XX = ITS communications network directly applicable; XX = ITS network is supportive and XX is not applicable to this project). The National ITS Architecture is broken down into equipment packages and market packages. These facilitate implementation of specific functions. Tables 1.2-3 summarize Market Packages associated with National ITS Architecture. Table 1.2-4 summarizes the standards groups associated with developing ITS National Standards and Table 1.2-5 identifies some of the key ITS standards.

Figure 1.2-2: ITS Physical Architecture

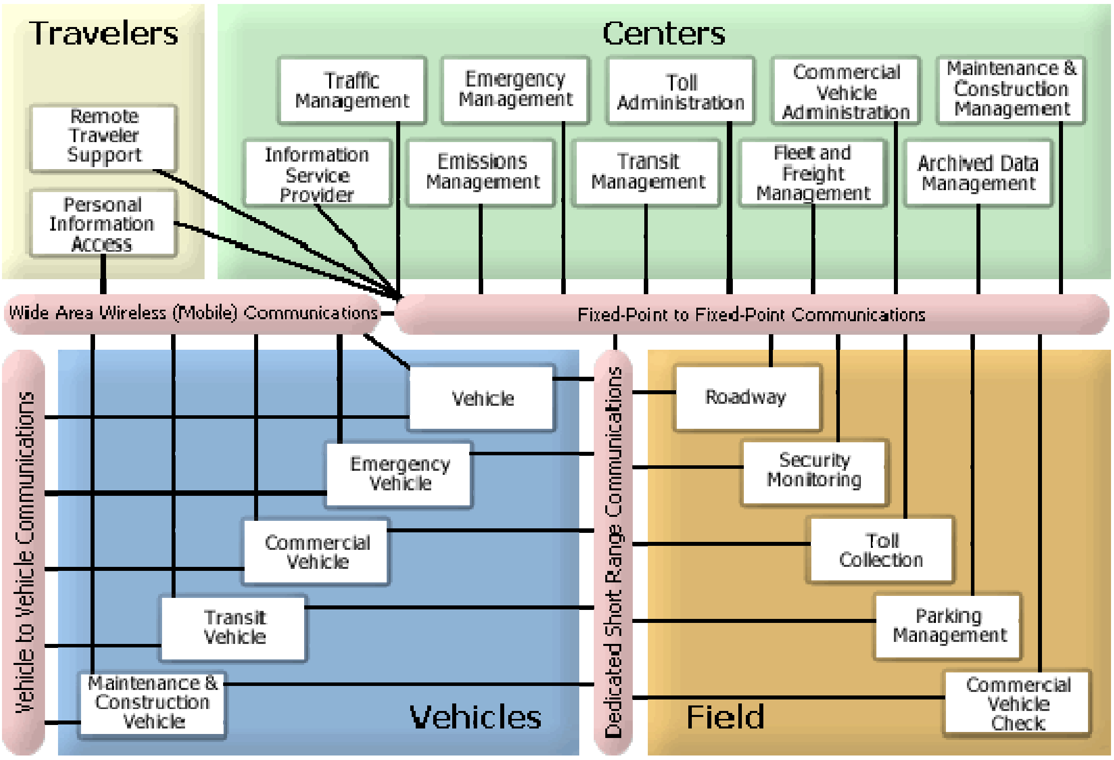


Table 1.2-1: ITS Physical Architecture Elements

Centers	Archived Data Management Subsystem (ADMS) Commercial Vehicle Administration (CVAS) Emergency Management (EM) Emissions Management (EMMS) Fleet and Freight Management (FMS) Information Service Provider (ISP) Maintenance and Construction Management (MCMS) Toll Administration (TAS) Traffic Management (TMS) Transit Management (TRMS)
Field	Commercial Vehicle Check (CVCS) Parking Management (PMS) Roadway Subsystem (RS)

	Security Monitoring Subsystem (SMS) Toll Collection (TCS)
Travelers	Personal Information Access (PIAS) Remote Traveler Support (RTS)
Vehicles	Commercial Vehicle Subsystem (CVS) Emergency Vehicle Subsystem (EVS) Maintenance and Construction Vehicle (MCVS) Transit Vehicle Subsystem (TRVS) Vehicle (VS)

Table 1.2-2: ITS User Services

1 Travel and Traffic Management (User Services Bundle*)

User Services*:

1.1 Pre-trip Travel Information
1.2 En-route Driver Information
1.3 Route Guidance
1.4 Ride Matching And Reservation
1.5 Traveler Services Information
1.6 Traffic Control
1.7 Incident Management
1.8 Travel Demand Management
1.9 Emissions Testing And Mitigation
1.10 Highway Rail Intersection

2 Public Transportation Management (User Services Bundle*)

User Services*:

2.1 Public Transportation Management
2.2 En-route Transit Information
2.3 Personalized Public Transit
2.4 Public Travel Security

3 Electronic Payment (User Services Bundle*)

User Services*:

3.1 Electronic Payment Services

4 Commercial Vehicle Operations (User Services Bundle*)

User Services*:

4.1 Commercial Vehicle Electronic Clearance
4.2 Automated Roadside Safety Inspection
4.3 On-board Safety And Security Monitoring
4.4 Commercial Vehicle Administrative Processes
4.5 Hazardous Materials Security And Incident Response
4.6 Freight Mobility

5 Emergency Management (User Services Bundle*)

User Services*:

5.1 Emergency Notification And Personal Security

5.2 Emergency Vehicle Management
5.3 Disaster Response And Evacuation

6 Advanced Vehicle Safety Systems (User Services Bundle*)

User Services*:

6.1 Longitudinal Collision Avoidance
6.2 Lateral Collision Avoidance
6.3 Intersection Collision Avoidance
6.4 Vision Enhancement For Crash Avoidance
6.5 Safety Readiness
6.6 Pre-crash Restraint Deployment
6.7 Automated Vehicle Operation

7 Information Management (User Services Bundle*)

User Services*:

7.1 Archived Data

8 Maintenance And Construction Management (User Services Bundle*)

User Services*:

8.1 Maintenance And Construction Operations

Table 1.2-3: ITS National Architecture Market Packages (Ref. FHWA)

Service Area	Market Package	Market Package Name
Archived Data Management	AD1	ITS Data Mart
	AD2	ITS Data Warehouse
	AD3	ITS Virtual Data Warehouse
Public Transportation	APTS1	Transit Vehicle Tracking
	APTS2	Transit Fixed-Route Operations
	APTS3	Demand Response Transit Operations
	APTS4	Transit Passenger and Fare Management
	APTS5	Transit Security
	APTS6	Transit Maintenance
	APTS7	Multi-modal Coordination
	APTS8	Transit Traveler Information
Traveler Information	ATIS1	Broadcast Traveler Information
	ATIS2	Interactive Traveler Information
	ATIS3	Autonomous Route Guidance
	ATIS4	Dynamic Route Guidance
	ATIS5	ISP Based Trip Planning and Route Guidance
	ATIS6	Integrated Transportation Management/Route Guidance
	ATIS7	Yellow Pages and Reservation
	ATIS8	Dynamic Ridesharing
	ATIS9	In Vehicle Signing
Traffic Management	ATMS01	Network Surveillance
	ATMS02	Probe Surveillance
	ATMS03	Surface Street Control
	ATMS04	Freeway Control
	ATMS05	HOV Lane Management
	ATMS06	Traffic Information Dissemination

	ATMS07	Regional Traffic Control
	ATMS08	Traffic Incident Management System
	ATMS09	Traffic Forecast and Demand Management
	ATMS10	Electronic Toll Collection
	ATMS11	Emissions Monitoring and Management
	ATMS12	Virtual TMC and Smart Probe Data
	ATMS13	Standard Railroad Grade Crossing
	ATMS14	Advanced Railroad Grade Crossing
	ATMS15	Railroad Operations Coordination
	ATMS16	Parking Facility Management
	ATMS17	Regional Parking Management
	ATMS18	Reversible Lane Management
	ATMS19	Speed Monitoring
	ATMS20	Drawbridge Management
	ATMS21	Roadway Closure Management
Vehicle Safety	AVSS01	Vehicle Safety Monitoring
	AVSS02	Driver Safety Monitoring
	AVSS03	Longitudinal Safety Warning
	AVSS04	Lateral Safety Warning
	AVSS05	Intersection Safety Warning
	AVSS06	Pre-Crash Restraint Deployment
	AVSS07	Driver Visibility Improvement
	AVSS08	Advanced Vehicle Longitudinal Control
	AVSS09	Advanced Vehicle Lateral Control
	AVSS10	Intersection Collision Avoidance
	AVSS11	Automated Highway System
Commercial Vehicle Operations	CVO01	Fleet Administration
	CVO02	Freight Administration
	CVO03	Electronic Clearance
	CVO04	CV Administrative Processes
	CVO05	International Border Electronic Clearance
	CVO06	Weigh-In-Motion
	CVO07	Roadside CVO Safety
	CVO08	On-board CVO and Freight Safety & Security
	CVO09	CVO Fleet Maintenance
	CVO10	HAZMAT Management
	CVO11	Roadside HAZMAT Security Detection and Mitigation
	CVO12	CV Driver Security Authentication
	CVO13	Freight Assignment Tracking
Emergency Management	EM01	Emergency Call-Taking and Dispatch
	EM02	Emergency Routing
	EM03	Mayday and Alarms Support
	EM04	Roadway Service Patrols
	EM05	Transportation Infrastructure Protection
	EM06	Wide-Area Alert
	EM07	Early Warning System
	EM08	Disaster Response and Recovery
	EM09	Evacuation and Reentry Management
	EM10	Disaster Traveler Information
Maintenance & Construction Management	MC01	Maintenance and Construction Vehicle and Equipment Tracking
	MC02	Maintenance and Construction Vehicle Maintenance

	MC03	Road Weather Data Collection
	MC04	Weather Information Processing and Distribution
	MC05	Roadway Automated Treatment
	MC06	Winter Maintenance
	MC07	Roadway Maintenance and Construction
	MC08	Work Zone Management
	MC09	Work Zone Safety Monitoring
	MC10	Maintenance and Construction Activity Coordination

Table 1.2-4: Professional Associations Responsible for ITS National Standards (Ref. FHWA)

Standard Development Organizations (SDO) Home Page	Applicable Interfaces in the National ITS Architecture	ITS Standards Specific Sites
AASHTO, ITE, NEMA	Traffic Management Center to other Centers	National Transportation Communications for ITS Protocol(NTCIP)
	Traffic Management Center to Field Devices	
	Transit Center to other Centers and Vehicles	Transit Communications Interface Profile (TCIP)
ANSI	Commercial Vehicle Operations (CVO)-related system interfaces	Commercial Vehicle Information Systems Network (CVISN)
ASTM	Archived Data Management Center Interfaces	Archived Data
ASTM, IEEE	Vehicle to Vehicle; Vehicle to Roadside	Dedicated Short Range Communications (DSRC)
IEEE	Emergency Management Center to other Centers	Incident Management
EIA/CEA	Information Service Provider radio broadcast to mobile users	Mobile interfaces
ITE	Traffic Management Center to other Centers	Traffic Management (TMDD and MS/ETMCC)
	Roadside Signal Controllers	Advanced Transportation Controller(ATC)
SAE	Traveler Information (Information Service Provider interfaces)	Advanced Traveler Information Systems (ATIS)
	Location Referencing	
	Vehicle interfaces	ITS Data Bus

Table 1.2-5: Some Key ITS National Standards

IEEE Standards
IEEE 1512® - 2000 (Common Incident Management Message Sets for Use by Emergency Management Centers)
IEEE 1512.1® - 2003 (Traffic Management)
IEEE 1512.2® - 2004 (Public Safety)
IEEE 1512.3® - 2002 (Hazardous Materials)
IEEE P1512.4 – (Entities External to Centers)
IEEE 802.2 – 1998 Information Technology – Telecommunications and Information Exchange Between Systems – Local and Metropolitan Area Networks – Specific Requirements – Part 2 Logical Link Control 1998
NEMA/AASHTO ITS Standards
NEMA/AASHTO NTCIP Standards:
NTCIP C2F: NTCIP Center-to-Field Standards Group
NTCIP C2C: NTCIP Center-to-Center Standards Group
NTCIP 1201: Global Object Definitions
NTCIP 1202: Object Definitions for Actuated Traffic Signal Controller (ASC) Units
NTCIP 1203: Object Definitions for Dynamic Message Signs (DMS)
NTCIP 1204: Object Definitions for Environmental Sensor Stations (ESS)
NTCIP 1205: Object Definitions for Closed Circuit Television (CCTV) Camera Control
NTCIP 1206: Object Definitions for Data Collection and Monitoring (DCM) Devices
NTCIP 1207: Object Definitions for Ramp Meter Control (RMC) Units
NTCIP 1208: Object Definitions for Closed Circuit Television (CCTV) Switching Obsolete Technology; IP-Video Distribution is New Technology
NTCIP 1209: Data Element Definitions for Transportation Sensor Systems (TSS)
NTCIP 1210: Field Management Stations (FMS) - Part 1: Object Definitions for Signal System Masters
NTCIP 1211: Object Definitions for Signal Control and Prioritization (SCP)
NTCIP 1401: TCIP Common Public Transportation (CPT) Objects
NTCIP 1402: TCIP Incident Management (IM) Objects
NTCIP 1403: TCIP Passenger Information (PI) Objects
NTCIP 1404: TCIP Scheduling/Runcutting (SCH) Objects
NTCIP 1405: TCIP Spatial Representation (SP) Objects
NTCIP 1406: TCIP On-Board (OB) Objects
NTCIP 1407: TCIP Control Center (CC) Objects
NTCIP 1408: TCIP Fare Collection (FC) Business Area Objects
NTCIP 9001: NTCIP Guide
NTCIP 9010: XML Used for Center-to-Center Communications
Society for Automotive Engineers (SAE)
J2266: Location Reference Message Specifications
J2369: Standards for ATIS Message Sets Delivered Over Reduced Bandwidth Media
J2529: Rules for Standardizing Street Names and Route Identification
Motion Picture Expert Group
MPEG 2: Video Compression and Decompression Standard (ISO 13818)
MPEG 4: Video Compression Standard to Accommodate Regional
MPEG 4: Video Compression Standard to Accommodate Regional Interoperability. Part 10 includes narrow bandwidth and wide bandwidth communications and has been adopted by International Telecommunications Union (ITU) as H.264 Standard (ISO 14496)
Joint Photographic Expert Group (JPEG)
ISO 15444 Standard; JPEG 2000
Federal Geographic Data Committee (FDGC):

FGDC-STD-001-1998: Content Standards for Geospatial Metadata GFDC-STD-002: Spatial Data Transfer Standard
Electronic Industry Association (EIA):
EIA 794: Data Radio Channel (DARC) System
EIA 232, 422, 485: Copper Twisted Pair Serial Communications Standards used in ITS
American Society for Test and Materials (ASTM)
ASTM: E2259-03a: Standard Guide for Archiving and Retrieving ITS-Generated Data
ASTM: E2213-02e1: Standard Specification for Telecommunications and Information Exchange Between Roadside and Vehicle Systems – 5 GHz Band Dedicated Short Range Communications (DSRC) Medium Access Control and Physical Layer (PHY) Specifications
ASTM: E2158-01: Standard Specification for Dedicated Short Range Communication (DSRC) Physical Layer Using Microwave in the 902 – 928 MHz Band.
ASTM: Standard Provisional Specification for Dedicated Short Range Communication (DSRC) Data Link Layer

The International Standards Organization, under ISO 7498 Standard, defines the Open Systems Interface (OSI) Model. For interoperability, communications networks should be compatible with the OSI Model. Figure 1.2-3 illustrates the OSI Model, defining 7 layers requir3ed for communications compatibility. Figure 1.2-4 illustrates compatibility between two communications nodes utilizing the OSI Model. Figure 1.2-5 illustrates the relationship of NTCIP Protocol to the OSI Model. Figure 1.2-6 is a graphic summary of the NTCIP Protocol deployment Options. Note that NTCIP 9010 defines XML as an alternate to CORBA and DATEX fro Center-to-Center communications.

Figure 1.2-3: OSI Model (Ref: Wikipedia)

OSI Model			
	Data unit	**Layer**	**Function**
Host layers	Data	Application	Network process to application
		Presentation	Data representation and encryption
		Session	Interhost communication
	Segments	Transport	End-to-end connections and reliability (TCP)
Media layers	Packets	Network	Path determination and logical addressing (IP)
	Frames	Data link	Physical addressing (MAC & LLC)
	Bits	Physical	Media, signal and binary transmission

Figure 1.2-4: Communicating Using the OSI Model (Ref: Webopedia)

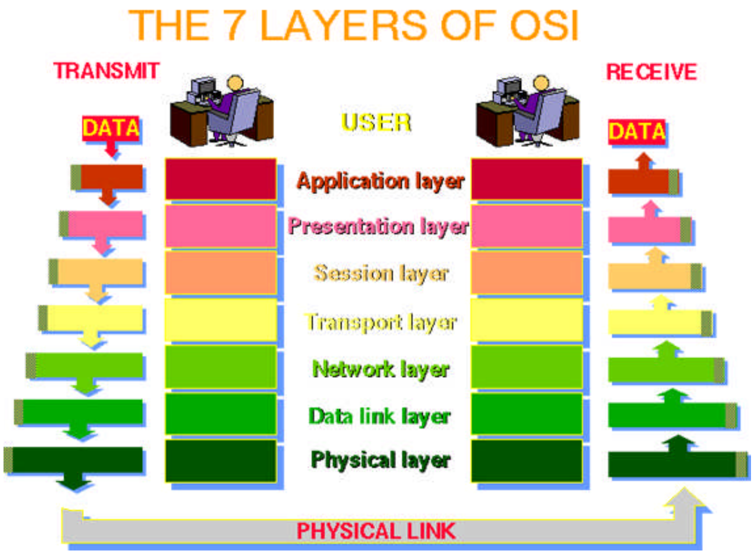


Figure 1.2-5: Relation of ISO Defined Communications Layers and NTCIP Layers

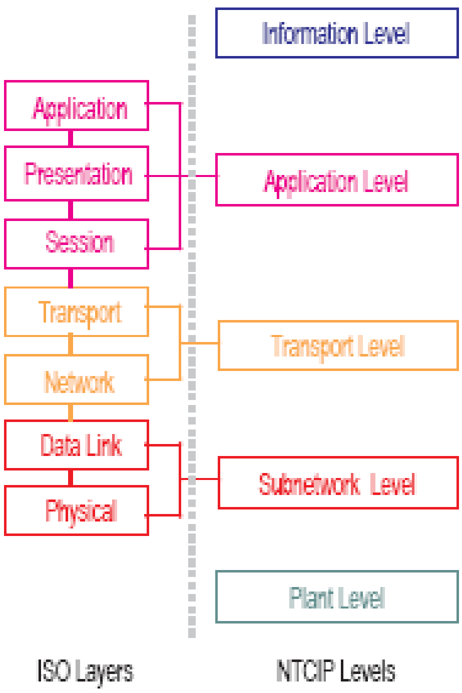
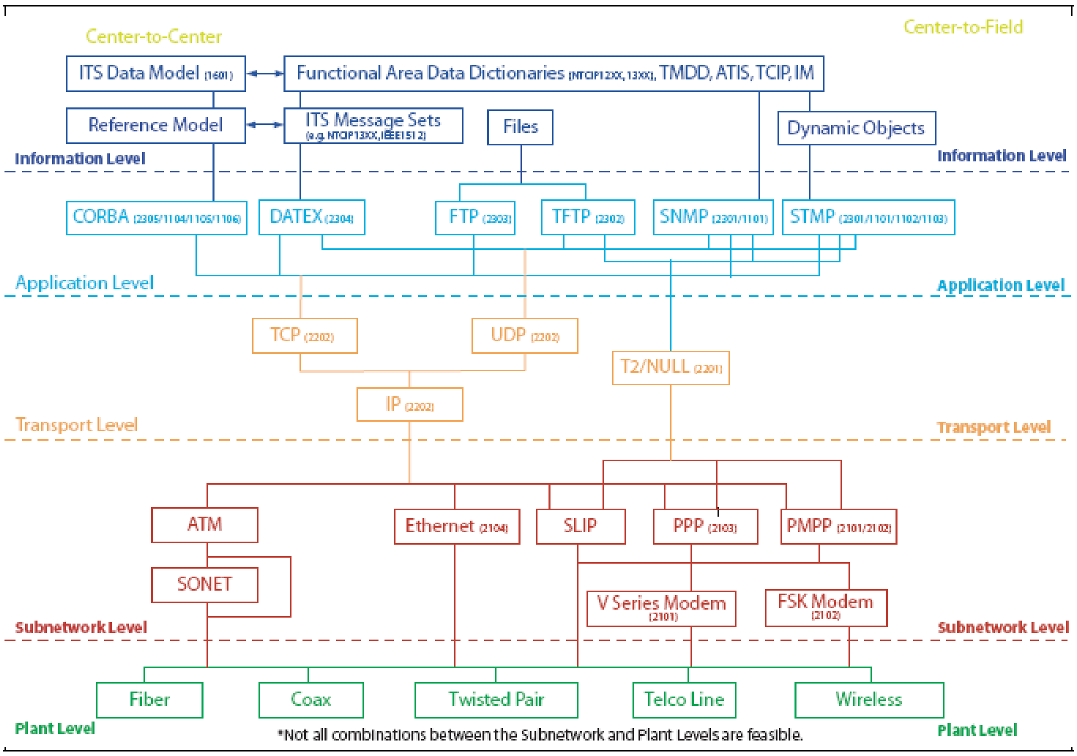


Figure 1.2-6: NTCIP Defined Communications Options (Reference: NTCIP 9001 V03.02)



Center-to-Center communications seems to be transitioning to TCP-IP at the Transport Level, Ethernet at the Subnet Level and Fiber at the Plant Level with XML becoming the protocol standard of choice at the Applications Level (NTCIP Model Reference). While wireless is being deployed in support of last mile communications with ITS field devices and may be utilized for backhaul in smaller ITS systems, the larger jurisdictions are deploying fiber because bandwidth is not limited and interference with other communications networks, as possible with wireless, is not an issue with fiber. Furthermore, fiber communications is much less susceptible to heavy storm conditions, including lightning.

1.2.1 Existing ITS Architecture

The MAG Arterial ITS Plan for the Phoenix Metropolitan Region (2006) provides the high level ITS architecture presented in figure 1.2.1-1. This figure identifies the jurisdictions associated with ITS architecture. AZtech, the name given to the architecture associated with an FHWA model deployment project oriented towards regional ITS interoperability, is operational in the MAG region. Figure 1.2.1-2 presents the AZtech system high-level diagram. Due to the rapid deployment requirement as well as model deployment funding limitations, AZtech utilized leased communications services with limited communications bandwidth. Simple interoperability was implemented. Also, the original AZtech objective was to deploy ITS on Priority Arterial Corridors as identified in the mid-1990s regional ITS Plan. The ITS Plan identified both North-South and East-West Priority Corridors and eight of each were originally identified as deployment candidates. To make corridors intelligent (SMART) requires sensors, messaging devices as well as a supporting communications infrastructure. As jurisdictions develop permanent ITS infrastructure on Priority Corridors, full intelligence can be achieved because adequate communications bandwidth will be available to support required multimedia linkage from field to ITS Centers. The deployment of a well-planned, regional communications network should provide the infrastructure to meet ITS data interchange needs between centers without compromise because of inadequate bandwidth.

Figure 1.2.1-1: High-level ITS Architecture Defined by MG for the Phoenix Area [Ref: MAG Arterial ITS Plan for the Phoenix Metropolitan Region (2006)]

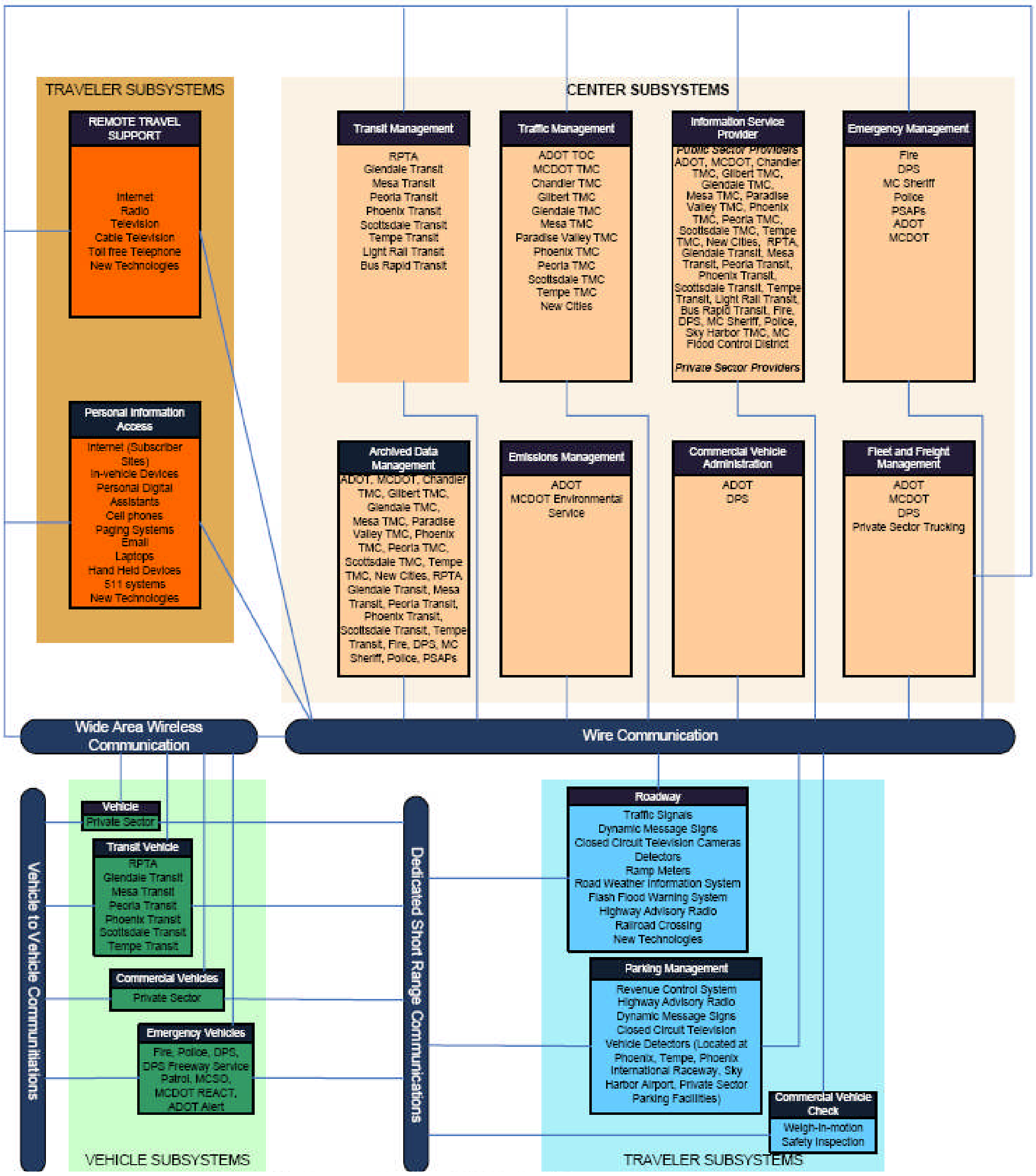
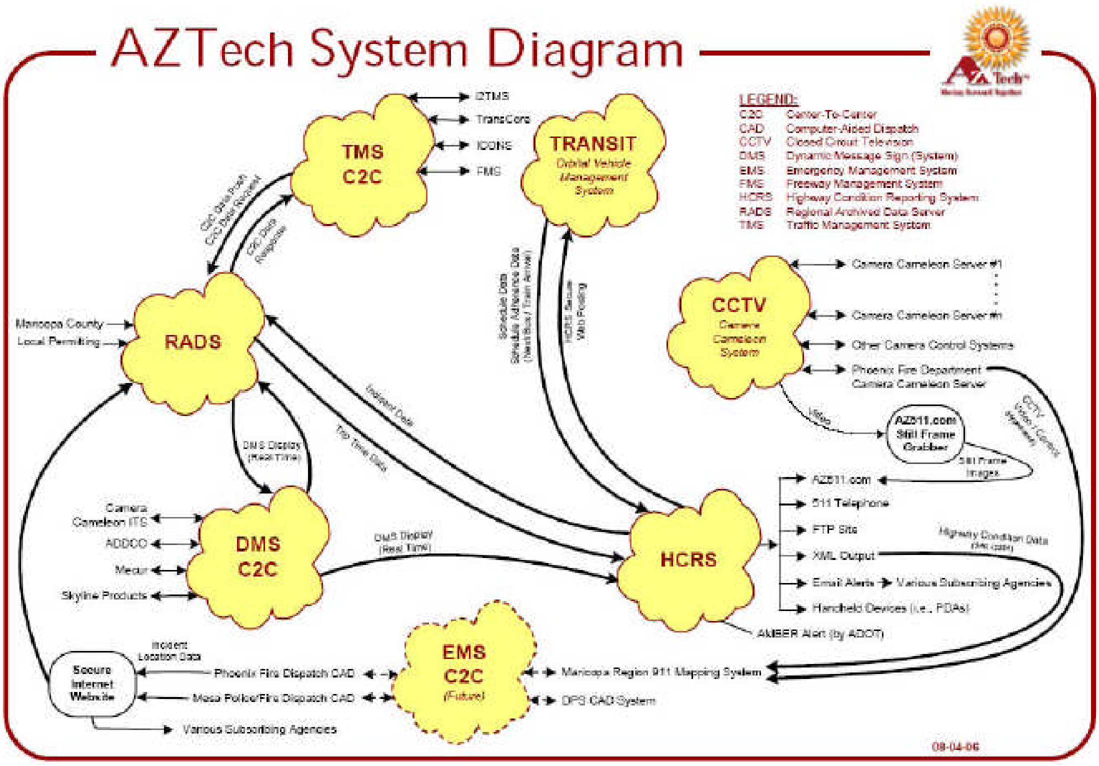


Figure 1.2.1-2: AZtech System Diagram [Ref: MAG Arterial ITS Plan for the Phoenix Metropolitan Region (2006)]



1.3 Existing ITS Infrastructure within the Region

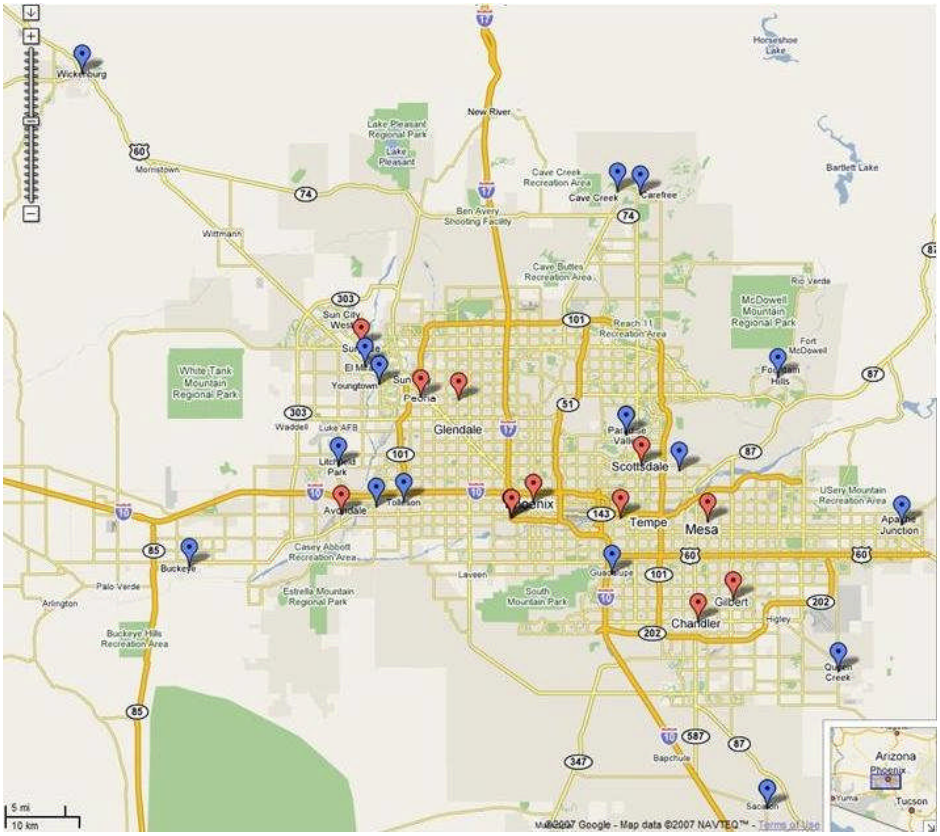
1.3.1 Traffic Management Centers (TMC)

ITS Traffic Management Centers currently deployed in the MAG region are summarized in table 1.3.1-1. As jurisdictional population grows and arterial corridors are added, TMCs will be improved and jurisdictions currently without TMCs are anticipated to deploy them. For a general planning guideline, a jurisdiction with a population of 20,000 is the probable threshold for deploying a simple TMC. The ADOT FMS as well as the MCDOT TMC are included in the table. Figure 1.3.1-1 presents the location of the TMCs on an area map.

Table 1.3.1 -1: MAG Region ITS Centers

ITS Center	Physical Address
ADOT FMS	2302 W. Durango Phoenix, AZ 85009
Chandler	215 E. Buffalo St., Suite 201 Chandler, AZ 85225
Gilbert	90 E Civic Center Dr Gilbert, AZ 85296
Glendale	9658 N. 59th Ave Glendale, AZ 85301
Goodyear	200 S. Calle del Pueblo Goodyear, AZ
MCDOT	2302 W. Durango Phoenix, AZ 85009
Mesa	320 E. 6th St. Mesa, AZ 85201
Peoria	8401 W. Monroe Room 201 Peoria, AZ 85345
Phoenix	200 West Washington St. 6th Floor Phoenix, AZ 85003
Scottsdale	7447 E. Indian School Rd # 205 Scottsdale, AZ
Surprise	12425 W. Bell Road Suite B-205 Surprise, AZ 85374
Tempe	945 W Rio Saldo Pkwy Tempe, AZ 85281

Figure 1.3.1-1: TMC Locations (Note Blue Represents City Hall Locations for Cities/Towns without TMCs; thus Potential Future Locations)



For the purpose of this plan, it is assumed that the TMC will be the primary interface location between the jurisdictional ITS Communications Network and the MAG Regional ITS Network.

1.3.2 MAG Area Public Safety Access Point (PSAP) Locations

PSAP, also known as emergency call centers, are typically co-located with emergency management centers, which provide the emergency dispatching function and emergency event management and coordination. The FCC Master PSAP Registry V2.59 (Street Location Approximated) was utilized to identify PASP locations as shown in table 1.3.2-1. PSAP's utilize 911 interfaces with the public telephone network (PTN) to receive emergency request calls from citizens. Calls may come from wired or wireless telephones. ITS mayday technology is being added to cellular telephones in accordance with FCC Rulings, that will provide location information to the call taker for cellular telephone calls. The automatic location identification (ALI) function for wireline calls is via caller identification (referred to as automatic number identification—ANI) and digital look up of the installed location of the wireline telephone. ALI function is very important to ITS because it provides the location of an incident for incident management as well as key dispatching information for emergency dispatchers. Associated with the Emergency Management Center is a wireless communications system facilitating communications between the dispatchers and first responders, and between first responders. Cities typically utilize the 800 MHz emergency frequency band and are starting to incorporate the new emergency frequencies in the 700 MHz frequency band allocated by FCC for emergency interoperability. County emergency resources normally utilize the 155 MHz emergency frequency band because of improved signal propagation and coverage. In any case, this communications resource is considered jurisdictional. Interoperability switches are being utilized to link City/Town 800 MHz communications frequencies with County 155 MHz frequencies. This plan does not include emergency wireless interoperability.

There is further a trend to deploy 4.85 GHz emergency communications in the form wireless Ethernet (either WiFi or WiMax) in an effort to achieve wider bandwidth communications between emergency vehicles and the emergency dispatcher. On-scene digital video transmission is of significant interest to the emergency dispatcher and is further of interest to the incident management function of a TMC. The TMC would receive this mobile digital video over the ITS link from the jurisdictional EMC to the jurisdictional TMC. Mobile digital video is further of interest to emergency hospitals who manage the incoming causality flow during a major emergency. The medical emergency management center of a hospital desires to receive location and estimated time of arrival information from emergency medical vehicles as well as information on the injured person (including images of wounds) so that proper preparation can be made to receive the person. It is even more important if the person was exposed to WDM agents and special handling is necessary at the medical center, including decontamination. These functions are coordinated between the Emergency Operations Center, the Emergency Management Center and the medical emergency management center of the hospital. This coordination may be accomplished through a regional ITS communications network.

Table 1.3.2-1: MAG Area PSAP Locations

FCC PSAP ID	PSAP	Address
400	Arizona State University Police Department	120 E 5th St. Tempe, AZ 85281
401	Avondale Police Department	11485 W Civic Center Dr, Avondale, AZ 85323
406	Buckeye Police Department	100 N Apache Rd Ste D Buckeye, AZ 85326
409	Capitol Police (Secondary PSAP)	1700 W Washington St Ste B15 Phoenix, AZ 85007
412	Chandler Police Department	250 East Chicago St.

		Chandler, AZ 85225
423	Department Of Public Safety (Orphaned PSAP/No Longer Primary)	2102 West Encanto Blvd Phoenix, AZ 85009
426	El Mirage Police Department	14406 North Primrose St. El Mirage, AZ 85335
431	Ft McDowell Police Department	18580 E Toh Vee Cir Fort McDowell, AZ 85264
436	Gilbert Police Department	75 E Civic Center Dr Gilbert, AZ 85296
437	Glendale Police Department	6835 N 57th Dr Glendale, AZ 85301
439	Goodyear Police Department	111 S Litchfield Rd Goodyear, AZ 85338
454	Luke Air Force Base Fire Department	Luke Air Force Base, AZ
457	Maricopa County Sheriff's Office	100 W. Washington, Ste 1900 Phoenix, AZ 85003
458	Mesa Police Department	130 North Robson Mesa AZ 85201
470	Paradise Valley Police Department	6433 E Lincoln Dr Paradise Valley, AZ 85253
473	Peoria Police Department	8343 W Monroe St Peoria, AZ 85345
474	Phoenix Department Of Public Safety (Orphaned PSAP/No Longer Primary)	2102 West Encanto Blvd Phoenix, AZ 85009
475	Phoenix Fire Department (Orphaned PSAP/No Longer Primary)	150 S. 12th St. Phoenix, AZ 85034
476	Phoenix Police Department	620 W. Washington St. Phoenix, AZ 85003
7907	Rural Metro Fire Department (Secondary PSAP)	4141 N. Granite Reef Rd. Scottsdale, AZ 85251
7889	Salt River Tribal Police	10,005 E. Osborn Road Scottsdale, AZ 85256
491	Scottsdale Police Department	8401 E. Indian School Rd. Scottsdale, AZ 85251
502	Surprise Police Department	14312 W. Tierra Buena Surprise, AZ 85374
503	Tempe Police Department	120 East 5th St. Tempe, AZ 85281
505	Tolleson Police Department	9555 W Van Buren St Tolleson, AZ 85353
511	Wickenburg Police Department	155 N. Tegner St. #C. Wickenburg, AZ 85390
519	Youngtown Police Department (Orphaned PSAP/No Longer Primary)	12038 Clubhouse Square Youngtown, AZ 85363

Figure 1.3.2-1 illustrates the relative locations of MAG Region PSAPs and are assumed to be integrated with the EMCs, and EMCs integrated with jurisdictional TMCs. Figure 1.3.2-2 illustrates a generic architecture of jurisdictional integration of emergency and traffic management. This may vary based on the size of the city/town, whether the County is providing emergency services and furthermore whether emergency medical is privatized. Only the larger cities will be candidates for EOC deployment.

Figure 1.3.2-1: Map of MAG PSAP Facilities

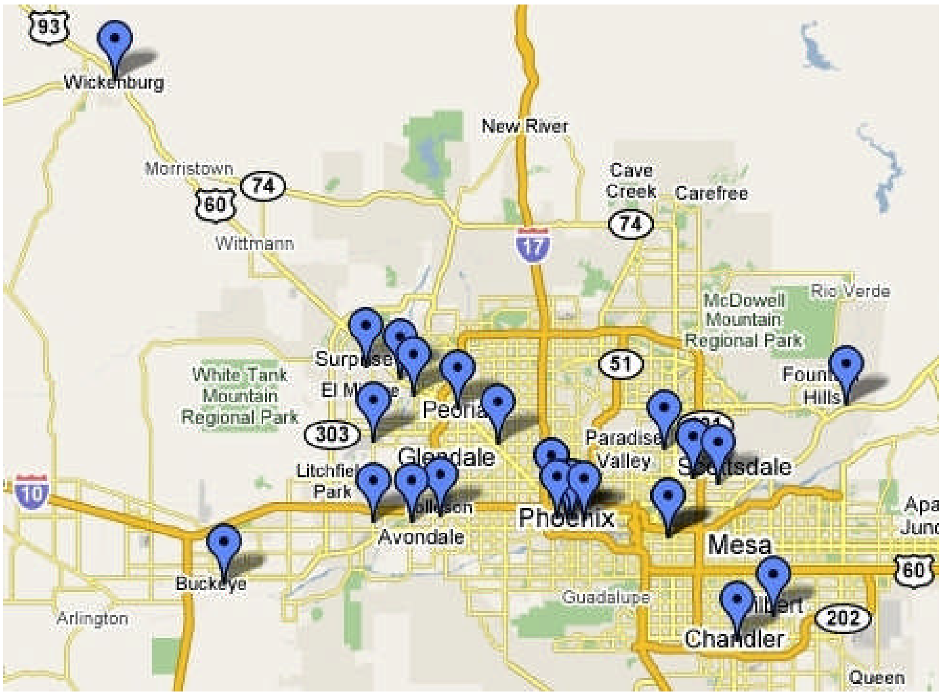
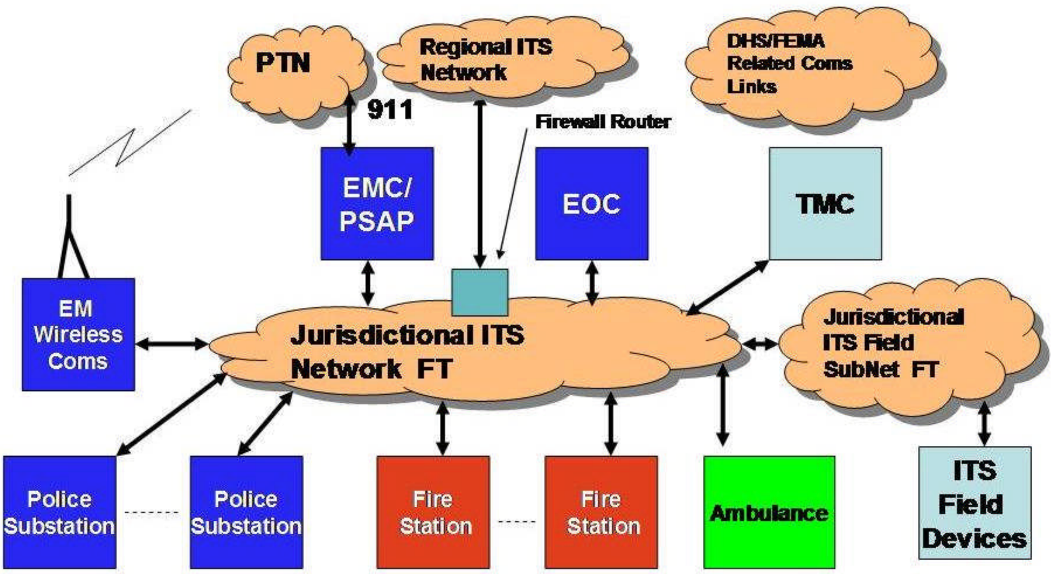


Figure 1.3.2-2: Generic Emergency-Traffic Management Integration



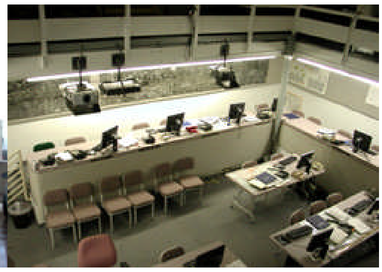
1.3.3 Emergency Operations Centers Currently Deployed in MAG Region

Table 1.3.3-1 summarizes identified County and State EOCs within the MAG Region.

Table 1.3.3-1: Emergency Operations Centers Locations

EOC Name	Physical Address
State of Arizona Primary EOC (SEOC)	Papago Park Military Reservation (PPMR), Phoenix
State Alternate EOC (ASEOC)	ASU Campus, Williams Gateway Complex
Arizona Division of Emergency Management	5636 E. McDowell Rd Phoenix, Arizona 85008
Emergency and Military Affairs Department	5636 E. McDowell Road Phoenix, Arizona 85008-3495
Maricopa County Emergency Management	2035 North 52nd Street Phoenix, AZ 85008





1.3.4 Public Transit

1.3.4.1 Valley Metro

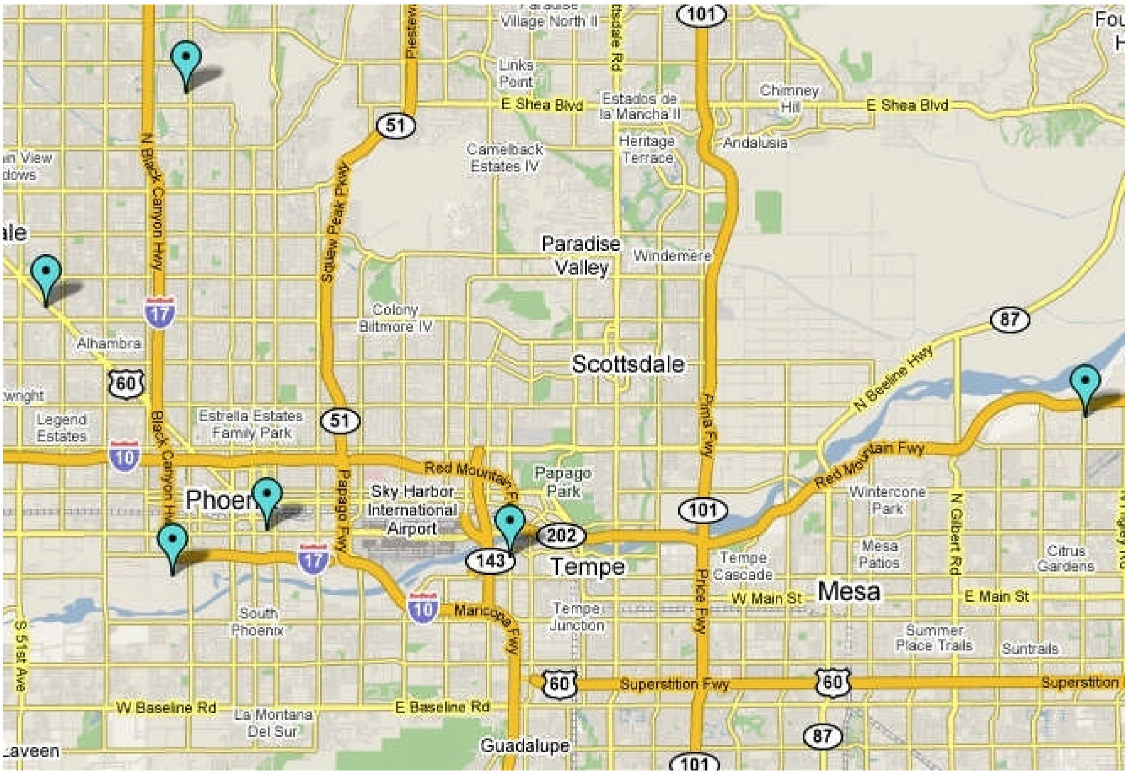
Valley Metro Bus Rapid Transit (BRT) facilities are summarized in table 1.3.4-1 and shown in figure 1.3.4-1.

Table 1.3.4-1: Valley Metro Bus Rapid Transit (BRT) Operations Facilities Locations (Ref. Valley Metro)

Facility	Contractor	Modes Served	Primary Functions	Publicly Owned?
Valley Metro/ Phoenix South Division 2225 W Lower Buckeye Rd Phoenix	ATC1/ Phoenix	Fixed Route & DASH Shuttle	Heavy Vehicle Maintenance, LNG and Diesel Fueling, Cleaning, and Painting. Operator Dispatch and Regional Radio Support.	Yes
Valley Metro/ Phoenix North Division	ATC/ Phoenix	Fixed Route	Vehicle Maintenance, LNG and Diesel Fueling, Vehicle Cleaning, and Operator	Yes

2010 W Desert Cove Phoenix			Dispatch	
Valley Metro/ Mesa 3320 N Greenfield Rd Mesa	ATC/ Mesa	Fixed Route & Paratransit	Vehicle Maintenance, CNG, LNG, and Diesel Fueling, Vehicle Cleaning and Operator Dispatch	Yes
Valley Metro/ Tempe 2031 W First St Tempe	ATC/ Tempe	Fixed Route	Vehicle Maintenance, LNG fueling, Vehicle Cleaning, and Operator Dispatch	No
Valley Metro/ Phoenix 5150 N Tom Murray Glendale	Laidlaw Transit Services	Fixed Route	Vehicle Maintenance, Fueling, Cleaning, and Operator Dispatch	No
Phoenix Dial-a-Ride 1001 S 4th St Phoenix	MV Transportation	Paratransit & Alex Shuttle	Vehicle Maintenance, Fueling, Cleaning, and Operator Dispatch	No

Figure 1.3.4-1: Location of Valley Metro BRT Facilities



The METRO Operations and Maintenance Center is the hub of light rail assembly, maintenance and operations in the Valley. The center is located on

48th St. just south of Washington St. The 35-acre property has three main structures: the Maintenance of Way, Maintenance of Engineering and Light Rail Vehicle Wash buildings. Figure 1.3.4-2 illustrates the light rail system and figure 1.3.4-3 illustrates the location of the Operations and Maintenance Center. Figure 1.3.4-4 illustrates locations of Park and Ride locations. Park and Ride locations are typically candidate locations for traveler security devices, parking management technology and traveler information access (DMS and kiosk). Transit dispatching is located in the MAG building at 302 N. First Street. This is a key ITS center requiring integration into the regional communications network.

Figure 1.3.4-2: Light Rail System (Ref: Valley Metro Rail)

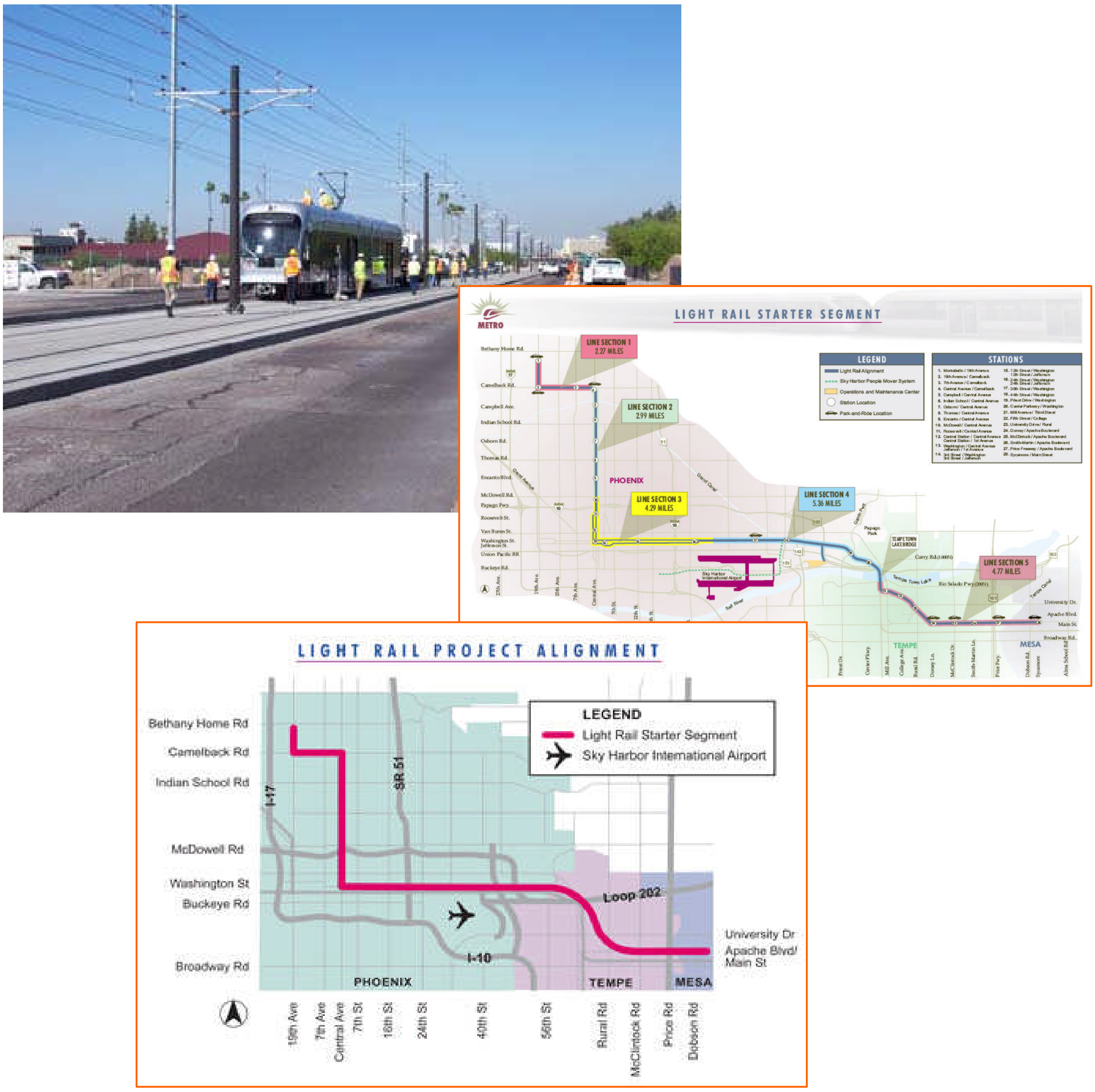


Figure 1.3.4-3: Light Rail System Operations Center Location

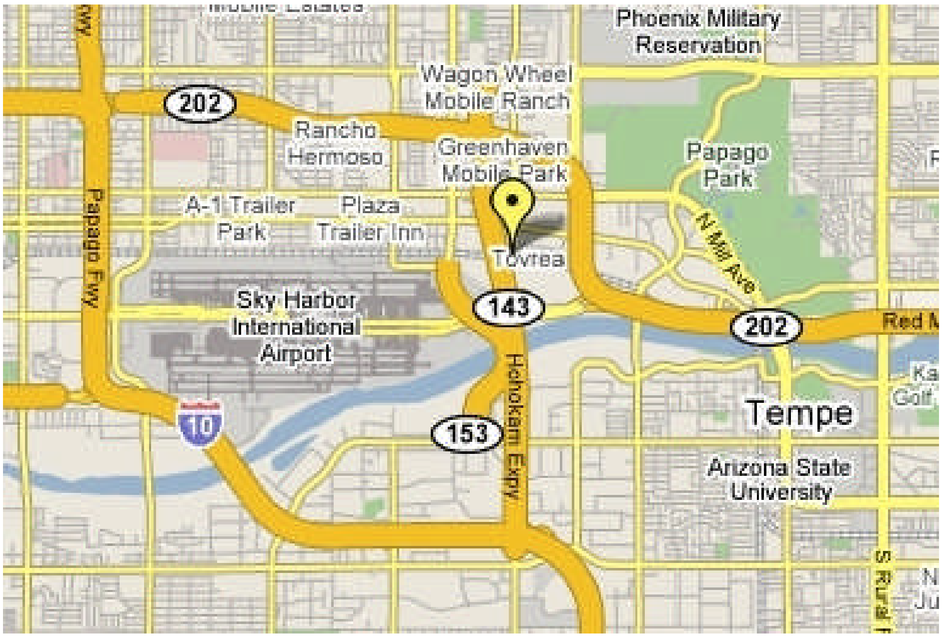
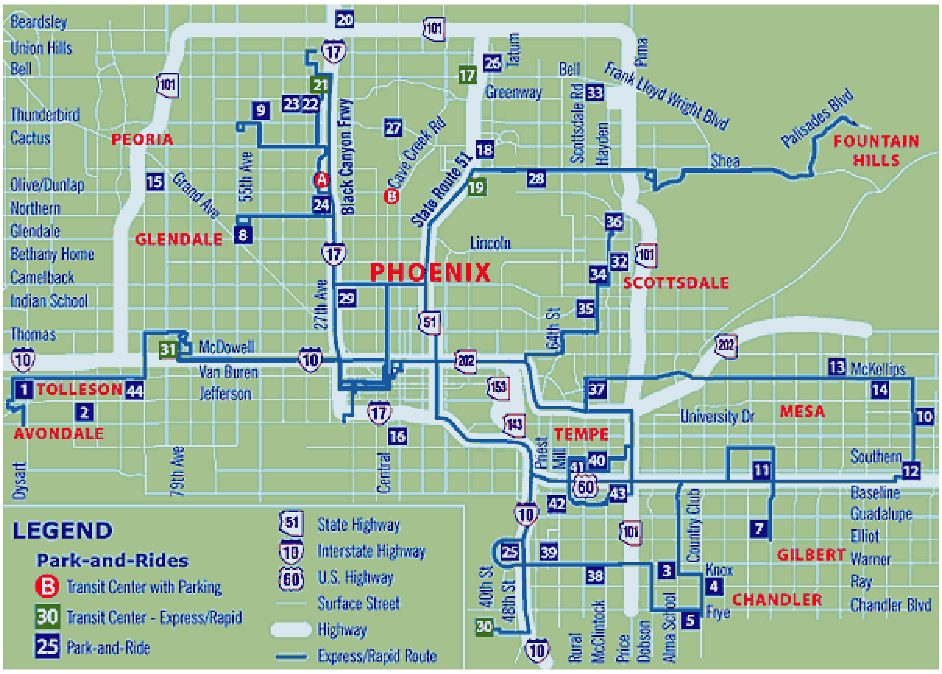


Figure 1.3.4-4: Park and Ride Locations (Ref. Valley Metro)

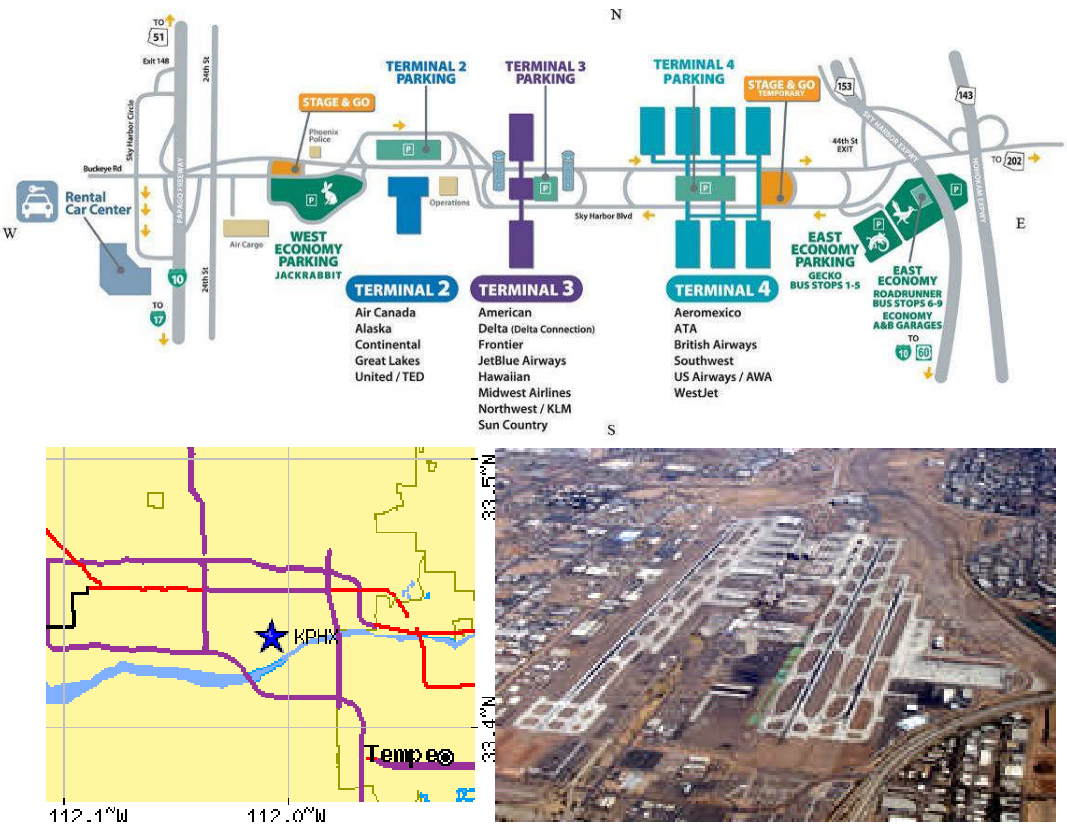


1.3.5 Area Airports

1.3.5.1 Phoenix Sky Harbor International Airport

Figure 1.3.5.1-1 illustrates the major international airport in the Phoenix area. The landside operations center of this airport should be integrated with the City of Phoenix jurisdictional communications network. Emergency Services of the airport will also be integrated with City of Phoenix Emergency Services. The Landside Operations Center should be responsible for traffic and parking management, curbside management, traveler safety and security, and traveler information.

Figure 1.3.5.1-1: Graphic of Sky Harbor International Airport



Lat/Long:	33-26-03.4000N / 112-00-41.7000W 33-26.056667N / 112-00.695000W 33.4342778 / -112.0115833
KPHX	Phoenix Sky Harbor International Airport Phoenix, Arizona, USA

1.3.5.2 Other Area Airports

Table 1.3.5.2-1 summarizes other airports (non-military) in the area. Williams Gateway is a candidate to be an alternate airport to Sky Harbor. Minor airports are candidates for private and corporate aircraft passengers to obtain traveler information related to surface travel. This can be accomplished by 511 access by a commuter terminal in the Fixed Based Operator's. (FBO) facilities or digital cellular access to 511.

Phoenix Goodyear Airport is designated as a general aviation reliever airport to Phoenix Sky Harbor International Airport and serves the needs of the West Valley by providing over 100,000 operations per year.

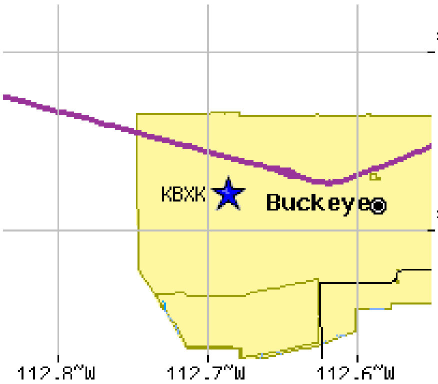
Table 1.3.5.2-1: MAG Region, Arizona Airports

ID	City	Name
KBXK	Buckeye	Buckeye Municipal Airport
KCHD	Chandler	Chandler Municipal Airport
P19	Chandler	Stellar Airpark
E63	Gila Bend	Gila Bend Municipal Airport
KGEU	Glendale	Glendale Municipal Airport
KGYR	Goodyear	Phoenix Goodyear Airport
E68	Maricopa	Estrella Sailport
KFFZ	Mesa	Falcon Field Airport
P48	Peoria	Pleasant Valley Airport
KDVT	Phoenix	Phoenix Deer Valley Airport
KPHX	Phoenix	Phoenix Sky Harbor International Airport
KIWA	Phoenix	Williams Gateway Airport
A39	Phoenix	Phoenix Regional Airport
KSDL	Scottsdale	Scottsdale Airport
E25	Wickenburg	Wickenburg Municipal Airport

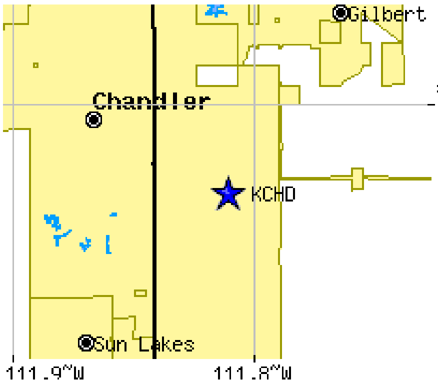
Figure 1.3.5.2-1: illustrates the location and provides an image of these airports.

Apache Junction Airport	**Buckhorn**	**Lat: 33.49**	**Lon:-111.64**
Carefree Airport	**Cave Creek**	**Lat:33.82**	**Lon: -111.90**

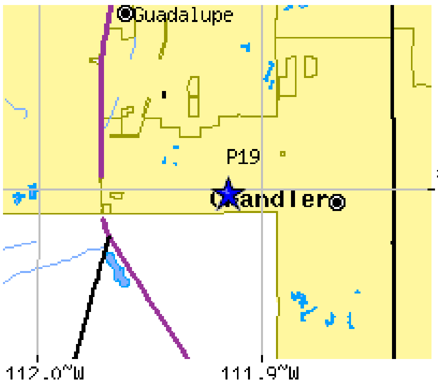
Buckeye: KBXK



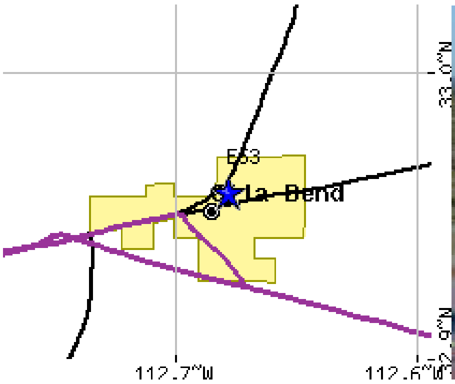
Chandler KCHD:



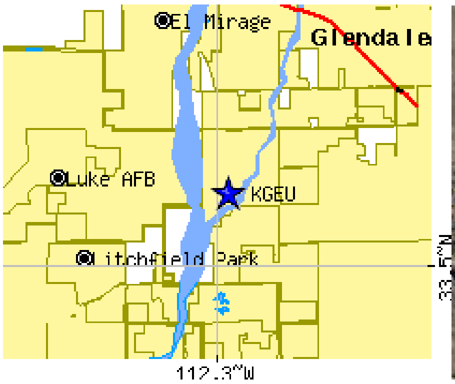
Chandler P19:



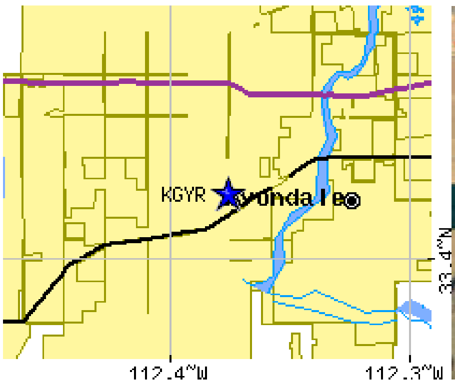
Gila Bend E63:



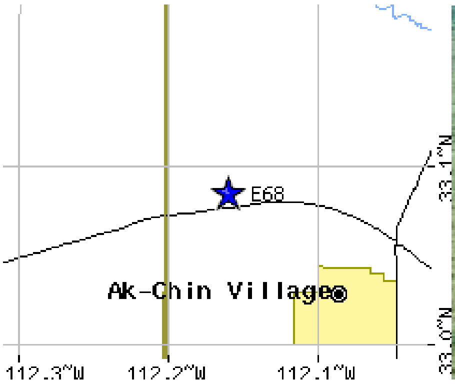
Glendale KGEU:



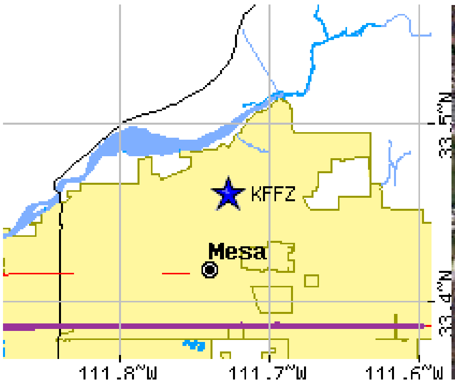
Goodyear KGYR:



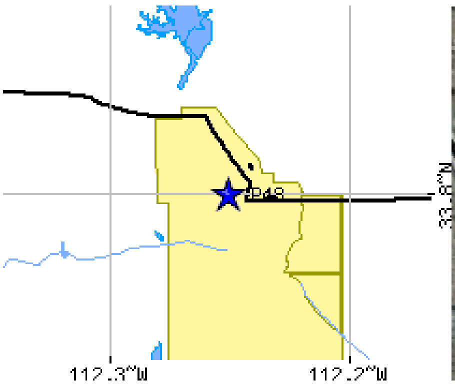
Maricopa E68:



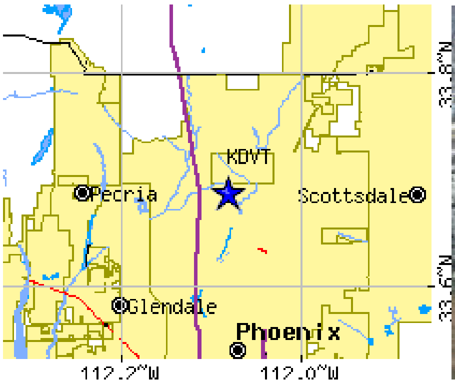
Mesa KFFZ:



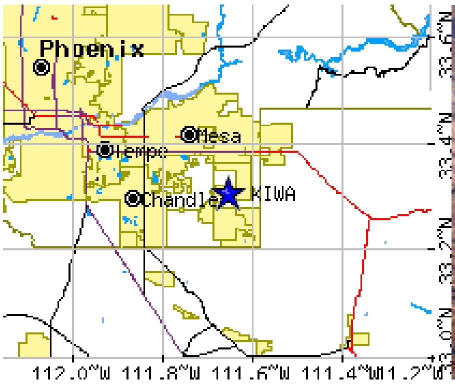
Peoria P48:



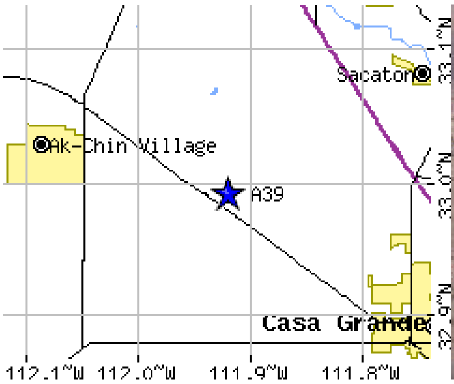
Phoenix KDVT:



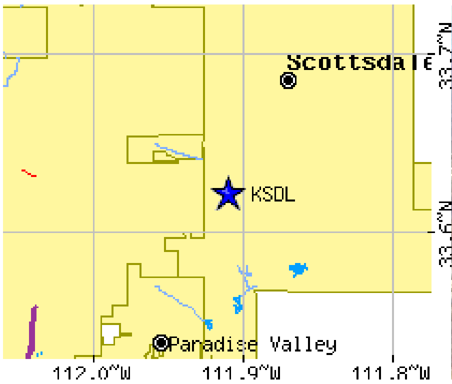
Phoenix KIWA:



Phoenix A39:



Scottsdale KSDL:



Wickenburg E25:

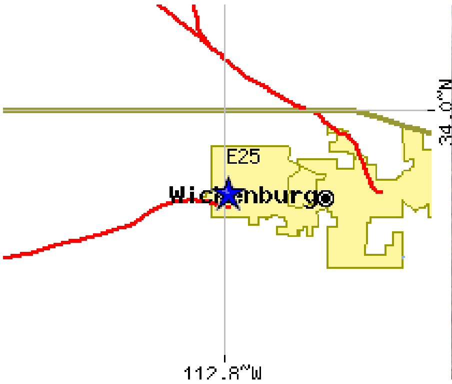
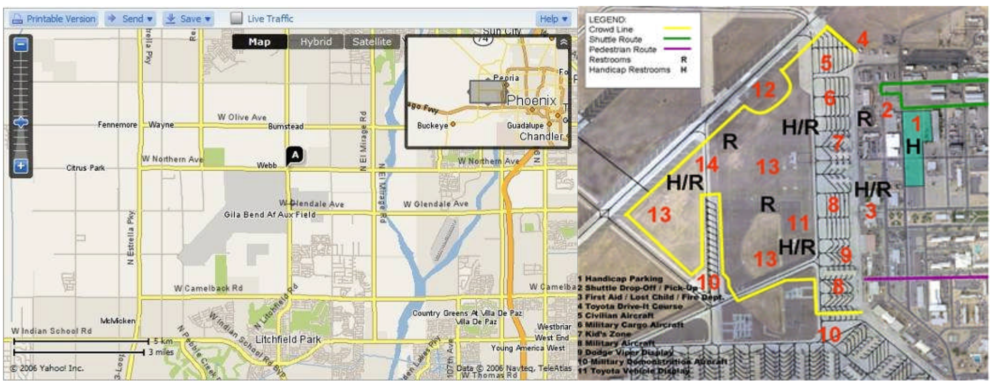


Figure 1.3.5.2-2 illustrates Luke AFB, which is in the MAG area. Luke AFB is part of the SEOC Emergency Support Plan and will be a major staging base in case of an emergency. Most major Military Gases have an Emergency Management Center, which manages on-base emergencies and is set up to provide mutual aid for surrounding jurisdictions under the coordination of the State Emergency Operations Center.

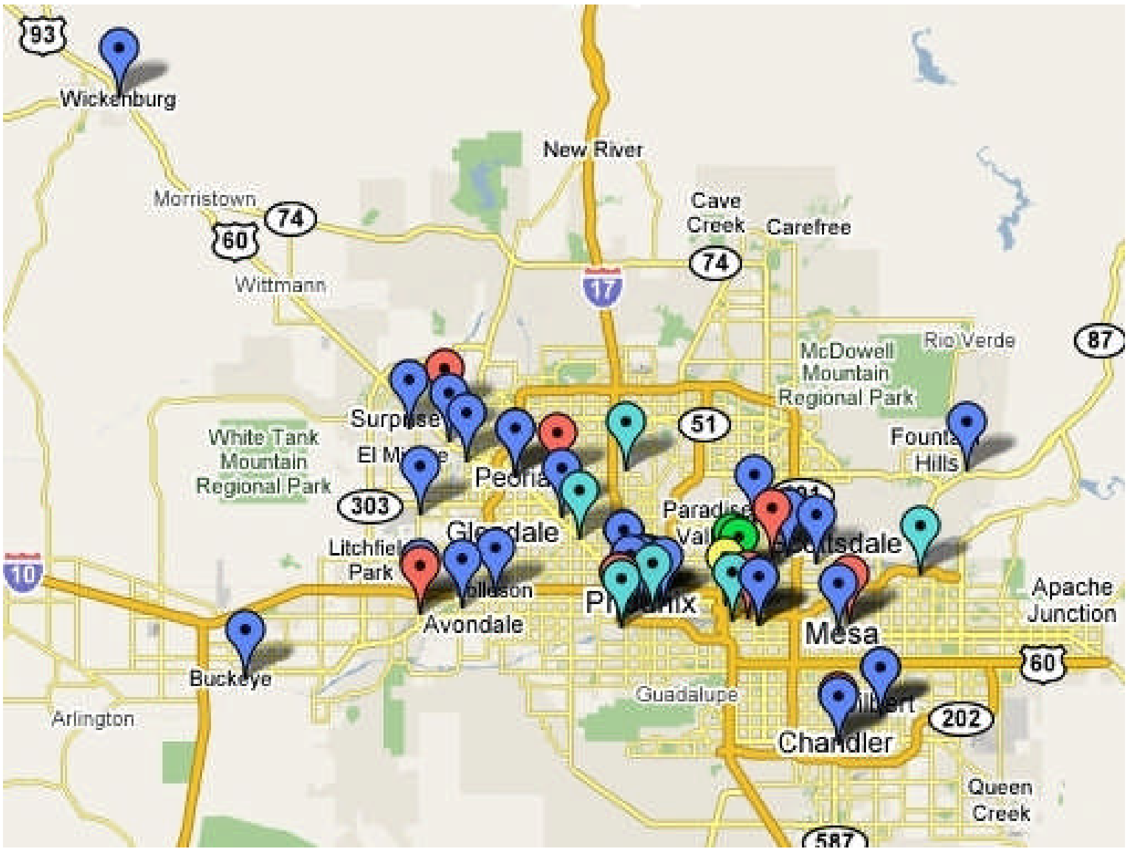
Figure 1.3.5.2-2: Luke Air Force Base



1.3.6 Google Map of all ITS MAG Facilities (Less Airports)

Figure 1.3.6-1 summarizes location of ITS related locations and centers (airports not included). Most are reasonably near the freeway network.

Figure 1.3.6-1: ITS Locations in the MAG Area



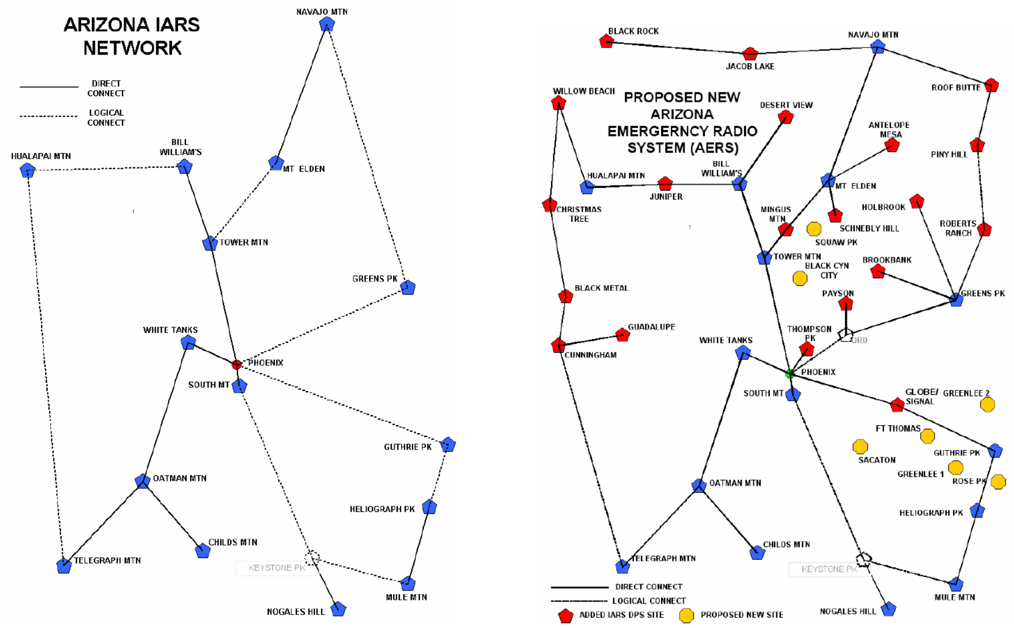
(Note: Dark Blue = PSAP Locations, Red = ITS Centers, Light Blue = BRT Dispatch Centers, Yellow = LRT Dispatch, Maintenance Yard, Green = EOC)

1.4 Communications Infrastructure Overview

1.4.1 Arizona IARS Network (DPS Microwave System)

DPS has a microwave system supporting emergency communications and linking emergency centers with wireless communications towers and transceiver equipment. Figure 1.4.1-1 illustrates this microwave network. It has limited bandwidth and is not a candidate to support regional interoperability other than the functions that it is currently performing related to linking emergency resources.

Figure 1.4.1-1: DPS Microwave Network Diagram



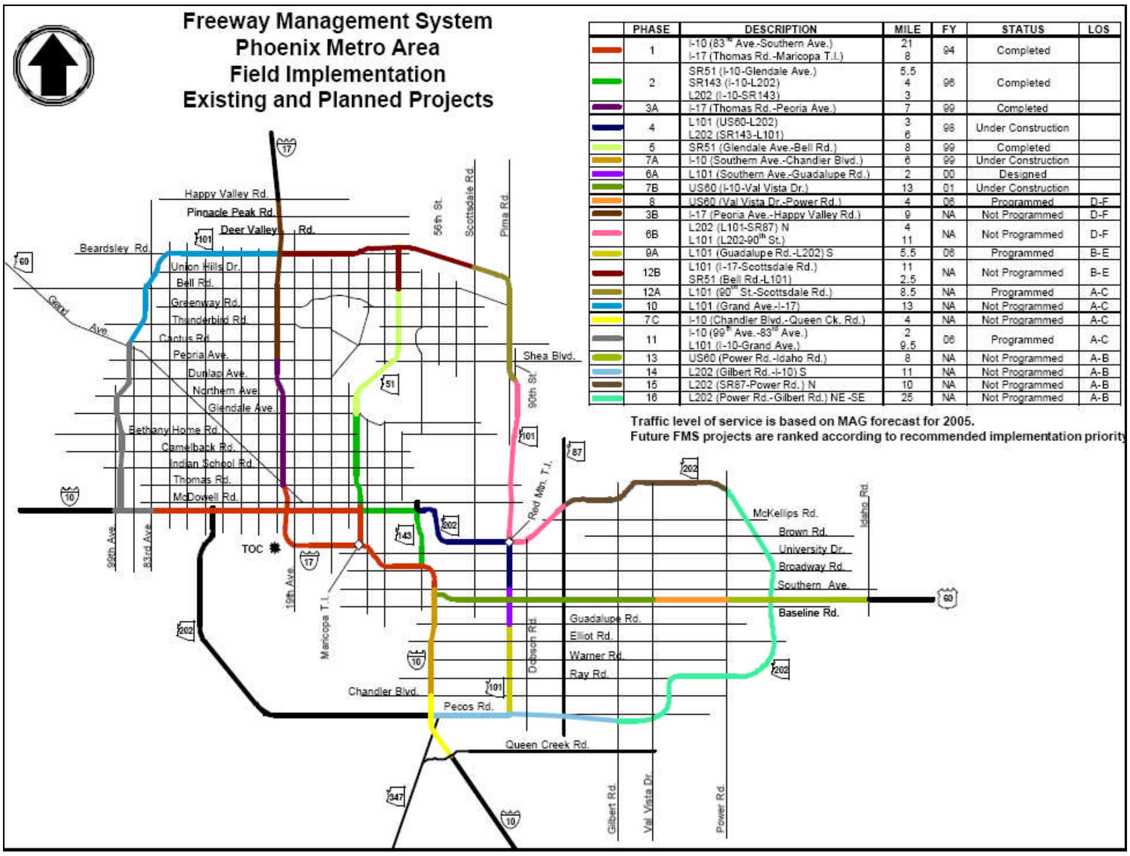
1.4.2 Arizona Department of Transportation (ADOT) MAG Area Deployment

ADOT has a freeway management system, which has been operational since the early 1990s. ADOT continues to expand the field infrastructure of FMS. The FMS field environment includes single mode fiber cable installed in conduit and interconnected to SONET terminal equipment installed at the freeway management center and in field-communications node buildings. ADOT also has an FM multiplexed communications link that supports analog video distribution and digital control (EIA 232) of deployed cameras. M1-0 or equivalent multiplexers provide interfaces for roadside ITS devices, interfaced via multi-dropped copper twisted pair or via optical transceivers (depending on deployment phase). NTSC based CCTV cameras are interfaced to communications node buildings utilizing video optical transceivers. The SONET network utilizes a patch switched, optical ring architecture and multiple rings are deployed covering freeway segments. The SONET network includes OC-3 and OC-12 terminal equipment. Table 1.4.2-1 lists the hierarchy of the most common SONET/SDH data rates. Figure 1.4.2-1 illustrates the ADOT FMS infrastructure that follows ADOT freeway corridors.

Table 1.4.2-1: Standard SONET Data Rates

Optical Level	Electrical Level	Line Rate (Mbps)	Payload Rate (Mbps)	Overhead Rate (Mbps)	SDH Equivalent
OC-1	STS-1	51.840	50.112	1.728	-
OC-3	STS-3	155.520	150.336	5.184	STM-1
OC-12	STS-12	622.080	601.344	20.736	STM-4
OC-48	STS-48	2488.320	2405.376	82.944	STM-16
OC-192	STS-192	9953.280	9621.504	331.776	STM-64
OC-768	STS-768	39813.120	38486.016	1327.104	STM-256

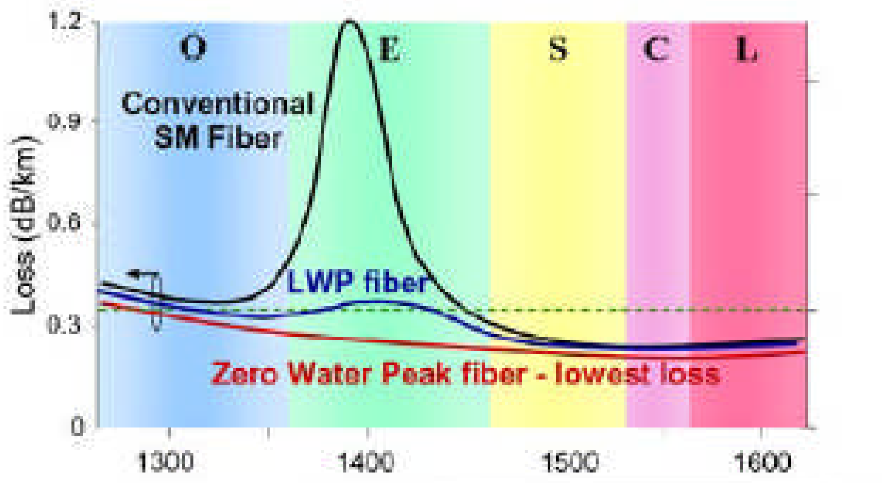
Figure 1.4.2-1: ADOT FMS Field Implementation Plans



ADOT has deployed some folded optical rings that are "unfolded" in future phases. Where a ring is folded in a single conduit, it is susceptible to failure should the conduit be cut. If conduit is laid down both sides of the freeway, then it has path diversity and a conduit/fiber cut will be automatically recovered using the path switched ring capability of SONET.

The major point to be made is that ADOT has deployed a major communications infrastructure in the MAG area. Currently ADOT has an overlay network with SONET providing analog multiplexed video from communications nodes to the FMC. The fiber supporting the ADOT field network represents various manufacturers and vintages. Figure 1.4.2-2 illustrates the difference in older, conventional single mode fiber and fiber designed to support wave division multiplexing from 1280 to 1640 nm. As data rates increase attention must be given to the chromatic dispersion, dispersion slope and polarization mode dispersion characteristics of the fiber, which can impact high data rate, broadband communications.

Figure 1.4.2-2: Single Mode Fiber Characteristic Comparison (Ref. OSF)



1.4.3 City of Phoenix and Metro Light Rail Management and Control Communications

Figure 1.4.3-1 illustrates the build-out plan for the light rail, public transportation system. For the most part, this system will be at grade. Thus, advanced ITS at grade crossing technology is applicable to intersections. The initial phase of deployment includes a 20 mile, Gig-E optical communications network. This network is fault tolerant and supports distributed intelligence at street/rail intersections utilizing Econolite ASC/NEMA TS-2 controllers implemented with NextPhase™ predictive firmware supporting transit priority. Should spare communications infrastructure be available perhaps it is a possible resource for use in the implementation of the regional ITS communications network.

Figure 1.4.3-1: Build-out Plans for Light Rail (Ref: Valley Metro)

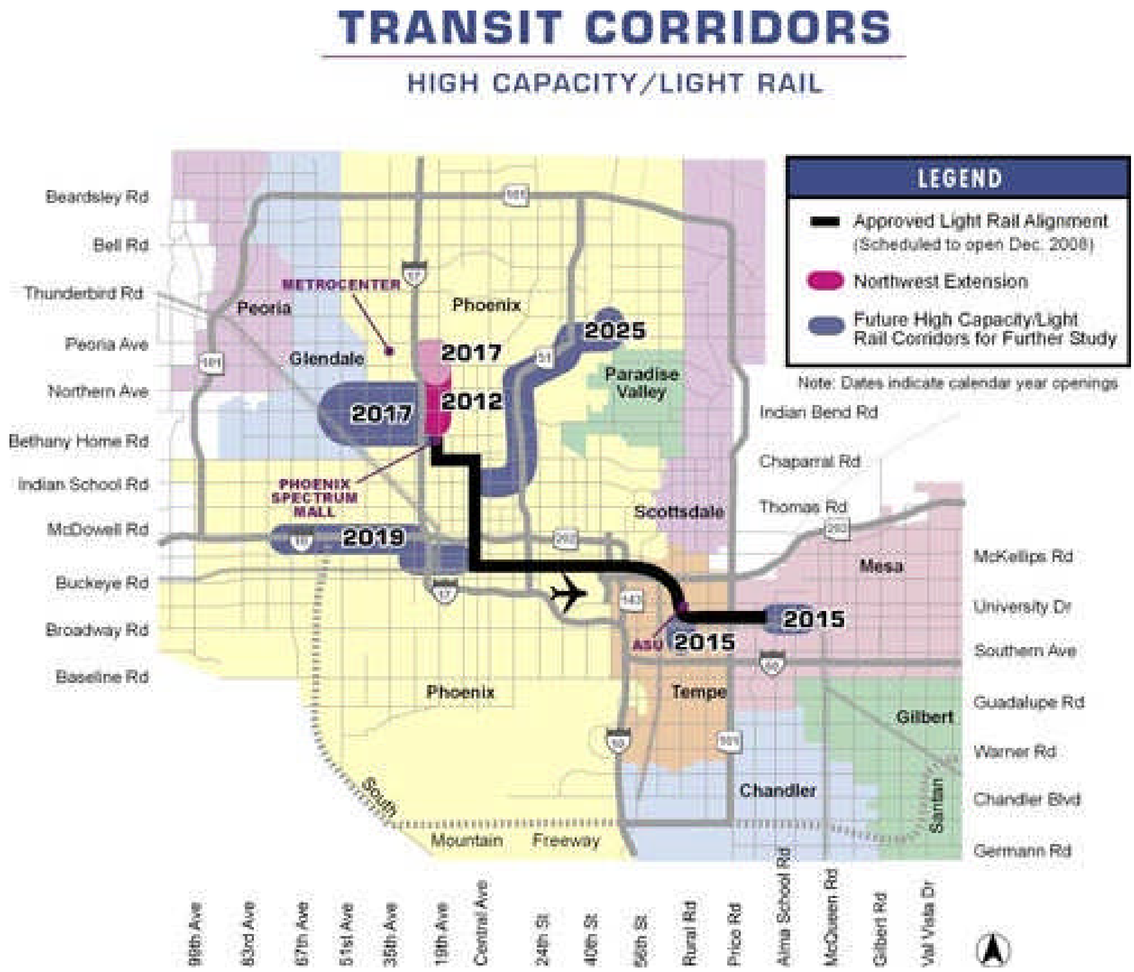
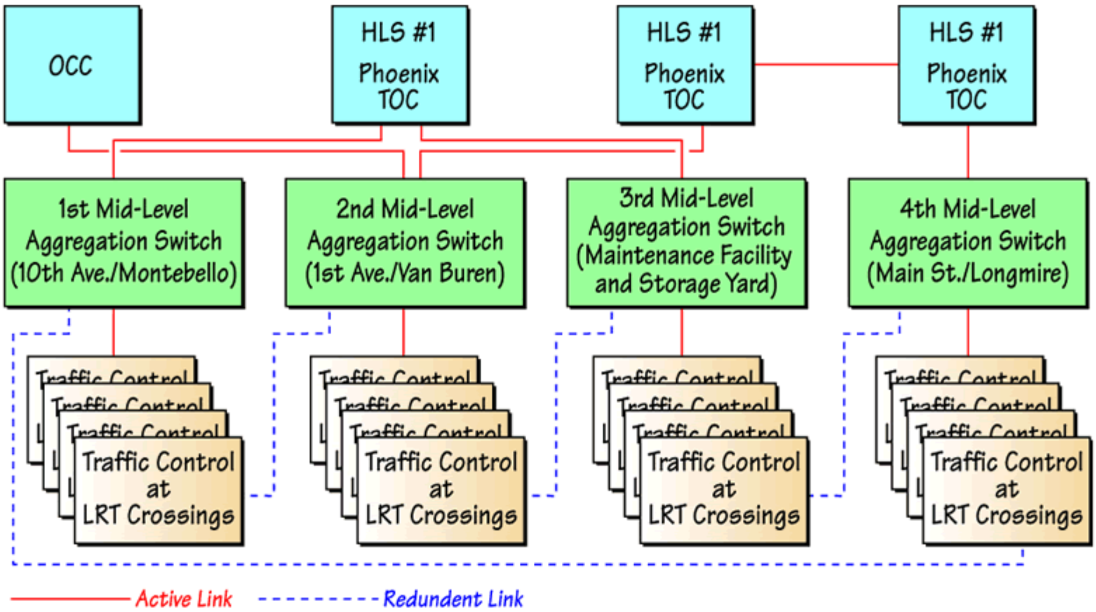


Figure 1.4.3-2: High Level Diagram of Light Rail Communications System Supported by a Gig-E Network (Ref: Fuller/Gupta, PBF Predictive Priority Signal Control from Concept to Implementation)



2.0 Communications Network Load Analysis

One of the basic requirements of a jurisdictional ITS communications network is to support communications between ITS roadside devices and the associated ITS management center. ITS National Architecture has defined information flows, interface standards, and protocol standards for standard utilized for ITS communications. Market Packages identify functional elements and associated information exchange. To understand regional ITS communications needs, an analysis was conducted to determine jurisdictional communications loads as well as regional communications loads. This was accomplished by utilizing MAG population growth information (which was derived from jurisdictional transportation plans) and relating population to typical ITS deployment. A similar technique was utilized in the NCHRP 3-51 Study, which addressed advanced communications for ITS. Also utilized was information in the FHWA's ITS Deployment Statistics Report for 2006 as well as information provided by some of the jurisdictions related to current ITS deployment and deployment plans for the next five years.

It is important to understand that the ITS deployment projections are only for the purpose of evaluating current and future bandwidth projections for jurisdictional networks and further determining information available for regional coordination and management. Thus, the deployment device numbers do not represent a requirement, but provide a planning guide for communications. The generic model utilized, based on population, provides a reasonable basis fro planning. Some jurisdictions, which have a large tax base and are aggressive in ITS deployment, may exceed deployment estimates; others that have less financial resources or do not support a vision of aggressive ITS deployment may have fewer devices deployed. However, considering all jurisdictions the model should reasonably represent communications requirements.

3.0 Developing ITS Device Deployment Information for Communications Planning

Table 3.0-1 presents the projected population growth for the MAG area. **Table 3.0-2** presents the growth rate of the various jurisdictions within the planning area based on information presented in **Table 3.0-1.**

Table 3.0-1: MAG Region Population Growth

MPA	Total Resident Population 2007	Total Resident Population 2010	Total Resident Population 2020	Total Resident Population 2025	Total Resident Population 2030
Apache Junction	41,104	53,024	63,629	76,354	91,625
Avondale	72,210	82,100	122,500	141,600	161,400
Buckeye	31,745	58,600	153,400	275,500	380,600
Carefree	3,785	4,000	4,800	4,800	4,900
Cave Creek	4,865	5,100	5,800	9,800	12,900
Chandler	235,450	260,000	286,600	287,000	288,600
County Areas	90,000	92,900	109,900	124,600	138,000
El Mirage	27,000	29,700	31,400	32,200	33,100
Fountain Hills	23,000	24,700	30,400	30,400	30,700
Gila Bend	1,815	2,800	6,000	12,500	17,800
Gila River*	3,000	3,200	4,200	4,700	5,200
Gilbert	185,030	202,800	280,300	281,900	290,500
Glendale	243,540	290,400	308,100	309,800	312,200
Goodyear	49,720	61,300	161,100	247,400	3 30,400
Guadalupe	5,000	5,200	5,500	5,500	5 ,600
Litchfield Park	4,890	7,000	13,700	13,700	14,200
Mesa	451,360	537,900	617,800	630,300	647,800
Paradise Valley	14,000	15,200	15,700	15,800	15,900
Peoria*	145,125	160,800	206,600	232,200	253,400
Phoenix	1,505,265	1,700,300	2,022,500	2,101,600	2,187,500
Queen Creek*	18,690	18,900	58,300	73,100	88,100
Salt River	7,000	7,400	7,500	7,500	7,500
Scottsdale	237,120	253,100	287,300	289,600	292,700
Surprise	98,140	115,200	213,300	312,300	395,500
Tempe	165,890	176,400	189,200	192,700	196,700
Tolleson	6,000	6,100	6,200	6,200	6,300
Wickenburg	6,285	7,700	10,000	14,800	16,000
Youngtown	5,000	5,400	6,200	6,300	6,600
TOTAL	3,646,029	4,187,424	5,227,729	5,740,354	6,231,625

Notes:

- MPA numbers rounded to nearest 100. County numbers may not add due to rounding. Please refer to Caveats for Interim Projections for complete notation on this series.
- Total resident population includes resident population in households and resident population in group quarters (dorms, nursing homes, prisons and military establishments)

Table 3.0-2: Population Growth Rate per Planning Period

MPA	2007 to 2010 Growth Rate	2010 to 2020 Growth Rate	2020 to 2025 Growth Rate	2025 to 2030 Growth Rate
Apache Junction	1.29	1.20	1.20	1.20
Avondale	1.14	1.49	1.16	1.14
Buckeye	1.85	2.62	1.80	1.38
Carefree	1.06	1.20	1.00	1.02
Cave Creek	1.05	1.14	1.69	1.32
Chandler	1.10	1.10	1.00	1.01
County Areas	1.03	1.18	1.13	1.11
El Mirage	1.10	1.06	1.03	1.03
Fountain Hills	1.07	1.23	1.00	1.01
Gila Bend	1.54	2.14	2.08	1.42
Gila River*	1.07	1.31	1.02	1.11
Gilbert	1.10	1.38	1.01	1.03
Glendale	1.19	1.06	1.01	1.01
Goodyear	1.23	2.63	1.54	1.33
Guadalupe	1.04	1.06	1.00	1.02
Litchfield Park	1.43	1.96	1.00	1.04
Mesa	1.19	1.15	1.02	1.03
Paradise Valley	1.09	1.03	1.01	1.01
Peoria*	1.11	1.29	1.12	1.09
Phoenix	1.21	1.19	1.04	1.04
Queen Creek*	1.02	3.08	1.25	1.21
Salt River	1.06	1.01	1.00	1.00
Scottsdale	1.07	1.14	1.01	1.01
Surprise	1.17	1.85	1.00	1.27
Tempe	1.06	1.07	1.02	1.02
Tolleson	1.02	1.02	1.00	1.02
Wickenburg	1.22	1.30	1.48	1.14
Youngtown	1.08	1.15	1.02	1.05
AV Growth for Period	1.15	1.25	1.10	1.09

Notes:
- MPA numbers rounded to nearest 100. County numbers may not add due to rounding. Please refer to Caveats for Interim Projections for complete notation on this series.
- Total resident population includes resident population in households and resident population in group quarters (dorms, nursing homes, prisons and military establishments)

Using information presented in Table 3.0-1, **Tables 3.0-3** through **3.0-7** were developed.

Table 3.0-3a: Projection of ITS Device Current Deployment

City/Town	Approximate Population 2007	Approximate Signalized Intersections 1/1300 Pop.	Actual Other Studies 2006/FHWA	CCTV 15 ea./100K	VIDS	DMS 1 ea./100K	HAR
Apache Junction	41,104	32		8	10	0	
Avondale	72,210	56	31	12/4	17/9	1/0	
Buckeye	31,745	24		9	7	0	
Carefree	3,785	3		-	1	0	
Cave Creek	4,865	4		-	1	0	
Chandler	235,450	181	192	39	54/57	0	0
County Area	90,000	69	142	18 (14)	21/43	1 (1)	0
El Mirage	27,000	21		5	6	0	
Fountain Hills	23,000	18	14	4	5/4	0	
Gila Bend	1,815	1		-	0	0	
Gila River	3,000	2		-	0	0	
Gilbert	185,030	142	131	4 (31)	43/39	2	0
Glendale	243,540	188	192/189	15/16 (44)	15 43/58	0	0
Goodyear	49,720	38		9	11	0	
Guadalupe	5,000	4		-	1	0	
Litchfield Park	4,890	4		-	1	0	
Mesa	451,360	347	367	60	104	4 (5)	0
Paradise Valley	14,000	11		2	3	0	
Peoria	145,125	112	77/82	0/1 (24)	30 34/25	0/1 (1)	0
Phoenix	1,505,265	1159	963	276	348/289	7 (15)	0
Queen Creek	18,690	14		3	4	0	
Salt River	7,000	6		1	2	0	
Scottsdale	237,120	182	283	80 (38)	56/85	20	0
Surprise	98,140	75		18	23	1	
Tempe	165,890	127	194	27	38/58	0 (2)	0
Tolleson	6,000	5		1	2	0	
Wickenburg	6,285	5		1	2	0	
Youngtown	5,000	4		-	1		
Subtotal	3,462,029	2834					
ADOT	N/A	N/A	161	109	48	67	0

Note: XX= Model; XX = FHWA 2006 Survey; XX = Jurisdictional Survey Input to this project

Table 3.0-3b: 2007 Projections and Actual (where available) of ITS Deployment within the MAG Area -- Extended

City/Town	Approximate Population 2007	Approximate Signalized Intersections 1/1300 Population	Other Traffic Sensors (2% of TCs	ESS * (2% of TCs	Speed Enforce (0.5% of TCs)	Rail Cross **	Red Light Enforce (1% of TCs)	HAR ***	Sec. & HAZMAT (0.05% of TCs
Apache Junction	41,104	32	1	1	0		0	0	0
Avondale	72,210	56	1	1	0		1/2	0	0
Buckeye	31,745	24	0	0	0		0	0	0
Carefree	3,785	3	0	0	0		0	0	0
Cave Creek	4,865	4	0	0	0		0	0	0
Chandler	235,450	181/192	4	4	1	23	1	0	1
County Area	90,000	69/142	3	3	0	5	1	0	0
El Mirage	27,000	21	0	0	0		0	0	0
Fountain Hills	23,000	18/14	0	0	0		0	0	0
Gila Bend	1,815	1	0	0	0		0	0	0
Gila River	3,000	2	0	0	0		0	0	0
Gilbert	185,030	142/131	3	3	1	10	1	0	1
Glendale	243,540	188/192	4	4	1	0	2/0	0	1
Goodyear	49,720	38	1	1	0		0	0	0
Guadalupe	5,000	4	0	0	0		0	0	0
Litchfield Park	4,890	4	0	0	0		0	0	0
Mesa	451,360	347/367	7	7	2	0	3	0	2
Paradise Valley	14,000	11	0	0	0		0	0	0
Peoria	145,125	112/77/82	2	2	1	2	1/0	0	1
Phoenix	1,505,265	1159/963	19	19	5		12/11	0	5
Queen Creek	18,690	14	0	0	0		0	0	0
Salt River	7,000	6	0	0	0		0	0	0
Scottsdale	237,120	182/283	4	4	1	0	3/14	0	1
Surprise	98,140	75	2	2	0		1	0	0
Tempe	165,890	127/194	3	3	1		2	0	1
Tolleson	6,000	5	0	0	0		0	0	0
Wickenburg	6,285	5	0	0	0		0	0	0
Youngtown	5,000	4	0	0	0		0	0	0
Subtotal	3,462,029	2834	54	54	13	40	26/36	0	13
ADOT	N/A	N/A	200					0	

Notes: * ESS includes Flood Sensors, Visibility Sensors and RWIS Supporting Homeland Security Plume Propagation Predictions
** Includes Light Rail At-Grade Crossings

Information Source: XX= Model; XX = FHWA 2006 Survey; XX = Jurisdictional Survey Input to this project

Table 3.0-4a: Jurisdictional ITS Deployment Projections Based on MAG Area Growth Projections for 2010

MPA	Total Resident Population 2010	Projected Signalized Intersections	Projected CCTV 18 CCTV/100K	Projected DMS 1 DMS/80K	VIDS 50% of TCs
Apache Junction	53,024	41	10	1	21
Avondale	82,100	63	15	1	32
Buckeye	58,600	45	11	1	23
Carefree	4,000	3	1	0	2
Cave Creek	5,100	4	1	0	2
Chandler	260,000	200	47	3	100
County Areas	92,900	72	17	1	36
El Mirage	29,700	23	5	0	12
Fountain Hills	24,700	19	5	0	10
Gila Bend	2,800	2	1	0	1
Gila River*	3,200	3	1	0	2
Gilbert	202,800	156	37	3	78
Glendale	290,400	223	52	4	112
Goodyear	61,300	47	11	1	24
Guadalupe	5,200	4	1	0	2
Litchfield Park	7,000	4	1	0	2
Mesa	537,900	414	99	7	207
Paradise Valley	15,200	12	3	0	6
Peoria*	160,800	124	29	2	62
Phoenix	1,700,300	1308	306	21	654
Queen Creek*	18,900	15	3	0	8
Salt River	7,400	6	1	0	3
Scottsdale	253,100	195	46	3	98
Surprise	115,200	89	21	1	45
Tempe	176,400	137	32	2	69
Tolleson	6,100	5	1	0	3
Wickenburg	7,700	6	1	0	3
Youngtown	5,400	4	1	0	2
TOTAL	4,187,424	3224	759	51	1619

Table 3.0-4a: Jurisdictional ITS Deployment Projections Based on MAG Area Growth Projections for 2010 ---Extended

MPA	Total Resident Population 2010	Projected Signalized Intersections	Non-VID Traffic Sensor (2% of TCs)	ESS * (2% or TCs)	Speed Enforce Sensor (0.5% of TCs	Rail Cross **	Red Light Enforce (2% of TCs)	HAR ***	Other Security & HAZMAT (1% of TCs
Apache Junction	53,024	41	1	1	0		1		0
Avondale	82,100	63	1	1	0		1		1
Buckeye	58,600	45	1	1	0		1		1
Carefree	4,000	3	0	0	0		0		0
Cave Creek	5,100	4	0	0	0		0		0
Chandler	260,000	200	4	4	1	23	4		2
County Areas	92,900	72	2	2	0	5	2		1
El Mirage	29,700	23	1	1	0		1		0
Fountain Hills	24,700	19	1	1	0		1		0
Gila Bend	2,800	2	0	0	0		0		0
Gila River*	3,200	3	0	0	0		0		0
Gilbert	202,800	156	3	3	1	10	3		0
Glendale	290,400	223	4	4	1	0	4	1	2
Goodyear	61,300	47	1	1	0		1	1	1
Guadalupe	5,200	4	0	0	0		0		0
Litchfield Park	7,000	4	0	0	0		0		0
Mesa	537,900	414	8	8	2	1	8		4
Paradise Valley	15,200	12	0	0	0		0		0
Peoria*	160,800	124	2	2	1	2	2		1
Phoenix	1,700,300	1308	26	26	7	20	26	1	13
Queen Creek*	18,900	15	0	0	0		0		0
Salt River	7,400	6	0	0	0		0		0
Scottsdale	253,100	195	4	4	1		4		2
Surprise	115,200	89	2	2	0		2		1
Tempe	176,400	137	3	3	1	9	3		1
Tolleson	6,100	5	0	0	0		0		0
Wickenburg	7,700	6	0	0	0		0		0
Youngtown	5,400	4	0	0	0		0		0
TOTAL	4,187,424	3224	64	64	15	70	64	3	30

Notes: * ESS includes Flood Sensors, Visibility Sensors and RWIS Supporting Homeland Security Plume Propagation Predictions
** Includes Light Rail At-Grade Crossings
*** HAR Deployment at Airports and Major Entertainment Centers

Table 3.05a: Jurisdictional ITS Deployment Projections Based on MAG Area Growth Projections for 2020

MPA	Total Resident Population 2020	Projected Signalized Intersections	Projected CCTV 25 CCTV/ 100K	Projected DMS 1 DMS/ 70K	VIDS 60% or TCs
Apache Junction	63,629	49	16	1	29
Avondale	122,500	94	31	2	56
Buckeye	153,400	118	38	2	71
Carefree	4,800	4	1	0	2
Cave Creek	5,800	5	2	0	3
Chandler	286,600	221	72	4	133
County Areas	109,900	85	28	2	51
El Mirage	31,400	24	8	0	14
Fountain Hills	30,400	23	8	0	14
Gila Bend	6,000	5	2	0	3
Gila River*	4,200	3	1	0	2
Gilbert	280,300	216	70	4	130
Glendale	308,100	237	77	4	142
Goodyear	161,100	124	40	2	74
Guadalupe	5,500	4	1	0	2
Litchfield Park	13,700	11	3	0	7
Mesa	617,800	475	155	9	285
Paradise Valley	15,700	12	4	0	7
Peoria*	206,600	157	52	3	94
Phoenix	2,022,500	1556	505	29	934
Queen Creek*	58,300	45	13	1	27
Salt River	7,500	6	2	0	4
Scottsdale	287,300	221	72	4	133
Surprise	213,300	164	53	3	98
Tempe	189,200	146	47	3	88
Tolleson	6,200	5	2	0	3
Wickenburg	10,000	8	3	0	5
Youngtown	6,200	5	2	0	3
TOTAL	5,227,729	4023	1308	73	2414

Table 3.0-5b: Jurisdictional ITS Deployment Projections Based on MAG Area Growth Projections for 2020 -- Extended

MPA	Total Resident Population 2020	Projected Signalized Intersections	Non-VID Traffic Sensor (2% of TCs)	ESS * (2% of TCs)	Speed Enforce (1% of TCs)	Rail Cross **	Red Light Enforce (2% of TCs)	HAR ***	Other Security & HAZMAT (1% of TCs)
Apache Junction	63,629	49	1	1	0		1		0
Avondale	122,500	94	2	2	1		2		1
Buckeye	153,400	118	2	2	1		2		1
Carefree	4,800	4	0	0	0		0		0
Cave Creek	5,800	5	0	0	0		0		0
Chandler	286,600	221	4	4	2	23	4		2
County Areas	109,900	85	2	2	1	5	2		1
El Mirage	31,400	24	1	1	0		1		0
Fountain Hills	30,400	23	1	1	0		1		0
Gila Bend	6,000	5	0	0	0		0		0
Gila River*	4,200	3	0	0	0		0		0
Gilbert	280,300	216	4	4	2	10	4		2
Glendale	308,100	237	5	5	2	6	5	1	2
Goodyear	161,100	124	3	3	1		3	1	1
Guadalupe	5,500	4	0	0	0		0		0
Litchfield Park	13,700	11	0	0	0		0		0
Mesa	617,800	475	5	5	5	1	5	1	5
Paradise Valley	15,700	12	0	0	0		0		0
Peoria*	206,600	157	3	3	2	2	3		2
Phoenix	2,022,500	1556	31	31	16	25	31	2	16
Queen Creek*	58,300	45	1	1	0		1		0
Salt River	7,500	6	0	0	0		0		0
Scottsdale	287,300	221	4	4	2		4		2
Surprise	213,300	164	3	3	2		3		2
Tempe	189,200	146	3	3	2	9	3		2
Tolleson	6,200	5	0	0	0		0		0
Wickenburg	10,000	8	0	0	0		0		0
Youngtown	6,200	5	0	0	0		0		0
TOTAL	5,227,729	4023	75	75	39	81	75	5	39

Notes: * ESS includes Flood Sensors, Visibility Sensors and RWIS Supporting Homeland Security Plume Propagation Predictions
** Includes Light Rail At-Grade Crossings
*** HAR Deployment at Airports and Major Entertainment Centers

Table 3.0-6a: Jurisdictional ITS Deployment Projections Based on MAG Area Growth Projections for 2025

MPA	Total Resident Population 2025	Projected Signalized Intersections	Projected CCTV 30 CCTV/ 100K	Projected DMS 1 DMS/ 60K	VIDS 70% of TCs
Apache Junction	76,354	59	23	1	41
Avondale	141,600	109	43	2	76
Buckeye	275,500	212	83	5	148
Carefree	4,800	4	1	0	3
Cave Creek	9,800	8	3	0	6
Chandler	287,000	220	86	5	154
County Areas	124,600	96	37	2	67
El Mirage	32,200	25	10	1	18
Fountain Hills	30,400	23	9	1	16
Gila Bend	12,500	10	4	0	7
Gila River*	4,700	4	1	0	3
Gilbert	281,900	217	85	5	152
Glendale	309,800	238	93	5	167
Goodyear	247,400	190	74	4	133
Guadalupe	5,500	4	2	0	3
Litchfield Park	13,700	11	4	0	8
Mesa	630,300	485	189	11	340
Paradise Valley	15,800	12	5	0	8
Peoria	232,200	179	70	4	125
Phoenix	2,101,600	1615	630	35	1131
Queen Creek	73,100	56	22	1	39
Salt River	7,500	6	2	0	4
Scottsdale	289,600	223	87	5	156
Surprise	312,300	240	94	5	68
Tempe	192,700	148	58	3	104
Tolleson	6,200	5	2	0	4
Wickenburg	14,800	11	4	0	8
Youngtown	6,300	5	2	0	4
TOTAL	5,740,354	4415	1657	95	3093

Table 3.0-6b: Jurisdictional ITS Deployment Projections Based on MAG Area Growth Projections for 2025—Extended

MPA	Total Resident Population 2025	Projected Signalized Intersections	Non-VID Traffic Sensor (2% of TCs)	ESS * (2% of TCs)	Speed Enforce (1% of TCs)	Rail Cross **	Red Light Enforce (2% of TCs	HAR ***	Other Security & HAZMAT (1% of TCs
Apache Junction	76,354	59	1	1	1		1		1
Avondale	141,600	109	2	2	1		2		1
Buckeye	275,500	212	4	4	2		4		2
Carefree	4,800	4	0	0	0		0		0
Cave Creek	9,800	8	0	0	0		0		0
Chandler	287,000	220	4	4	2	23	4		2
County Areas	124,600	96	2	2	1	5	2		1
El Mirage	32,200	25	1	1	0		1		0
Fountain Hills	30,400	23	1	1	0		1		0
Gila Bend	12,500	10	0	0	0		0		0
Gila River*	4,700	4	0	0	0		0		0
Gilbert	281,900	217	4	4	2	10	4		2
Glendale	309,800	238	5	5	2	6	5	1	2
Goodyear	247,400	190	4	4	2		4	1	2
Guadalupe	5,500	4	0	0	0		0		0
Litchfield Park	13,700	11	0	0	0		0		0
Mesa	630,300	485	10	10	5	1	10	1	5
Paradise Valley	15,800	12	0	0	0		0		0
Peoria	232,200	179	4	4	2	2	4		2
Phoenix	2,101,600	1615	32	32	16	35	32	2	16
Queen Creek	73,100	56	1	1	1		1		1
Salt River	7,500	6	0	0	0		0		0
Scottsdale	289,600	223	4	4	2		4		2
Surprise	312,300	240	5	5	2		5		2
Tempe	192,700	148	3	3	2	9	3		2
Tolleson	6,200	5	0	0	0		0		0
Wickenburg	14,800	11	0	0	0		0		0
Youngtown	6,300	5	0	0	0		0		0
TOTAL	5,740,354	4415	87	87	43	91	87	5	43

Notes: * ESS includes Flood Sensors, Visibility Sensors and RWIS Supporting Homeland Security Plume Propagation Predictions
** Includes Light Rail At-Grade Crossings
*** HAR Deployment at Airports and Major Entertainment Centers

Table 3.0-7a: Jurisdictional ITS Deployment Projections Based on MAG Area Growth Projections for 2030

MPA	Total Resident Population 2030	Projected Signalized Intersections	Projected CCTV 30/100K	Projected DMS 1 DMS/60K	VIDS 80% of TCs
Apache Junction	91,625	71	28	2	57
Avondale	161,400	124	48	3	99
Buckeye	380,600	293	114	6	234
Carefree	4,900	4	1	0	3
Cave Creek	12,900	10	4	0	8
Chandler	288,600	222	87	5	178
County Areas	138,000	106	41	2	85
El Mirage	33,100	26	10	1	21
Fountain Hills	30,700	24	9	1	19
Gila Bend	17,800	14	5	0	11
Gila River*	5,200	4	2	0	3
Gilbert	290,500	224	87	5	179
Glendale	312,200	240	94	5	192
Goodyear	330,400	254	99	6	203
Guadalupe	5 ,600	5	2	0	4
Litchfield Park	14,200	11	4	0	9
Mesa	647,800	498	194	11	398
Paradise Valley	15,900	12	5	0	96
Peoria*	253,400	195	76	4	156
Phoenix	2,187,500	1683	656	37	1346
Queen Creek*	88,100	68	26	2	54
Salt River	7,500	6	2	0	5
Scottsdale	292,700	225	88	5	180
Surprise	395,500	304	119	7	243
Tempe	196,700	151	59	3	121
Tolleson	6,300	5	2	0	4
Wickenburg	16,000	12	5	0	10
Youngtown	6,600	5	2	0	4
TOTAL	6,231,625	4796	1869	105	3602

Table 3.0-7b: Jurisdictional ITS Deployment Projections Based on MAG Area Growth Projections for 2030 -- Extended

MPA	Total Resident Population 2030	Projected Signalized Intersections	Non-VID Traffic Sensor (2% of TCs)	ESS * (2% of TCs)	Speed Enforce (1% of TCs)	Rail Cross**	Red Light Enforce (2% of TCs)	HAR***	Other Sec. & HAZMAT (1% of TCs
Apache Junction	91,625	71	1	1	1		1		1
Avondale	161,400	124	3	3	1		3		1
Buckeye	380,600	293	6	6	3		6		3
Carefree	4,900	4	0	0	0		0		0
Cave Creek	12,900	10	0	0	0		0		0
Chandler	288,600	222	4	4	2	23	4		2
County Areas	138,000	106	2	2	1	5	2		1
El Mirage	33,100	26	1	1	0		1		0
Fountain Hills	30,700	24	1	1	0		1		0
Gila Bend	17,800	14	0	0	0		0		0
Gila River*	5,200	4	0	0	0		0		0
Gilbert	290,500	224	5	5	2	10	5		2
Glendale	312,200	240	5	5	2	6	5	1	2
Goodyear	330,400	254	5	5	3		5	1	3
Guadalupe	5 ,600	5	0	0	0		0		0
Litchfield Park	14,200	11	0	0	0		0		0
Mesa	647,800	498	10	10	5	1	10	1	5
Paradise Valley	15,900	12	0	0	0		0		0
Peoria*	253,400	195	4	4	2	2	4		2
Phoenix	2,187,500	1683	34	34	17	35	34	2	17
Queen Creek*	88,100	68	1	1	1		1		1
Salt River	7,500	6	0	0	0		0		0
Scottsdale	292,700	225	5	5	2		5		2
Surprise	395,500	304	6	6	3		6		3
Tempe	196,700	151	3	3	2	9	3		2
Tolleson	6,300	5	0	0	0		0		0
Wickenburg	16,000	12	0	0	0		0		0
Youngtown	6,600	5	0	0	0		0		0
TOTAL	6,231,625	4796	91	91	47		91		47

Notes: * ESS includes Flood Sensors, Visibility Sensors and RWIS Supporting Homeland Security Plume Propagation Predictions
** Includes Light Rail At-Grade Crossings
*** HAR Deployment at Airports and Major Entertainment Centers

Table 3.0-8 presents the ADOT expansion plans for the Phoenix area freeway system. Table 3.0-9 was developed utilizing Table 3.0-8 information as well as information from the FHWA 2006 survey of ITS deployments in the Phoenix area. The current number of ITS devices deployed based on FHWA information was utilized to project future deployment based on additional miles of freeway. While it is true that DMS, access corridor traffic signal controllers and ramp metering deployments are a function of entrances and exits to the freeway, using comparative statistics is adequate for communications planning.

These tables provide ITS device deployment projections for the associated population growth planning periods as well as freeway ITS expansion plans. In the design of a communications network, consideration must be given to the projected bandwidth needs. The communications technology selected should be capable of meeting the bandwidth needs either through initial deployment or through modular expansion. The planning for the network should identify technology candidates that can be modularly expanded without having to replace the total network electronics.

Table 3.0-8: Planned MAG Area Freeway Expansion: Current to 2025
(Ref. ADOT)

PHASE	ROUTE	SEGMENT	MILES	FUND PRIORITY
8	US60	Val Vista to Power	4	2008
13 A	US60	Power to Crismon	4	2007
6B	Pima 101L	Princess to Red Mtn 202L	9	2007
12A	Pima 101L	I 17 to Princess	6	2007
9	Pima 101L	Guadalupe to Red Mtn 202L	5	2010
6B	Red Mtn 202L	RM: 101L to SR87	6	2009
Subtotal 2007 - 2010			**34**	
3A	I-17	AZ Canal to 101L	7	2013
3B	I-17	101L to Carefree	8	2013
12B	Pima 101L	I-17 to SR51	7	2013
12B	Pima 101L	SR51 to Princess	6	2013
12B	SR51	Bell Rd to 101L	2	2013
14A	San Tan 202L	SN:1-10 to Dobson	5	2013
14B	San Tan 202L	SN: Dobson to -Val Vista	7	2015
Subtotal 2013 - 2015			**42**	
10	Agua Fria 101L	Grand to I-17	12	2017
7C	I-10	Chandler Blvd to Queen Cr	4	2018
11A	I-10	Dysart to 83rd Ave	5	2016
11B	Agua Fria 101L	I-10 to Grand	9	2017
13 B	US60	Crismon to Meridian	2	2017
15A	202L	RM: SR 87 to Higley	4	2019
Subtotal 2017 - 2019			**36**	
15B	202L	RM: Higley to US60	8	2022
16	202L	ST: US60 to Val Vista	8	2022
17	I-17	Carefree to Anthem Way	5	2023
Subtotal 2022 - 2023			**21**	
Total			**97**	

Ref: ADOT RTP FUNDS FOR THE FREEWAY MANAGEMENT SYSTEM

Table 3.0-9: ADOT Phoenix Area Freeway Management System ITS Device Deployment Estimates (Ref: FHWA *2006 Survey* and FHWA *weather in Information*)

Phase	Current Per FHWA 2006 Survey	Freeway Expansion 2007 - 2010	Freeway Expansion 2010 - 2020	Freeway Expansion 2020 - 2025	Freeway Expansion 2025 - 2030	Total
Miles	87	25	45	21	30	208
ITS Device Deployment	ITS Device Deployment	Estimated ITS Device Deployment for Period	Estimated ITS Device Deployment for Period	Estimated ITS Device Deployment for Period	Estimated ITS Device Deployment for Period	Total ITS Device Deployment
Traffic Controllers	161	46	83	39	56	**385**
Traffic Data Collection	200	58	103	48	70	**479**
Ramp Metering	132	38	68	32	46	**316**
Surveillance CCTV (typical 1/mi)	109	31	56	26	38	**260**
VIDS/Traffic Data and Classification	48	14	25	12	17	**116**
Permanent DMS	119	34	62	29	41	**285**
HAR	0	0	0	0		**0**
Security/HAZMAT	10 (est.)	3	5	2	3	**23**
Speed Enforcement	0	0	10	10	10	**30**
ESS	15 (est.)	4	8	4	5	**36**
Probe Vehicle of Opportunity Sensors	0	0	10	5	5	**20**
DSRC VII	0	0	0	200	200	**400**

4.0 ITS Device Data Rates

There are different types of ITS devices that are deployed. Some devices report information upon an event being detected. Such devices include flood and visibility sensors, security alarm sensors, and speed and red light enforcement sensors. Thus, the data reported by these sensors is variable and generally does not represent a significant data load over a 24-hour period. Peak loading of these devices may be a megabit over a few seconds. Communications from the ITS center to these devices usually is insignificant and involves periodic polls to check the operational status and perhaps some maintenance communications for set up and testing. Again, this communications is insignificant over a 24-hour period.

Sensors that provide real time information are generally polled on a cycle basis. For communications load planning, a one-second poll cycle will be considered. Many jurisdictions utilize a one-second poll rate for traffic controllers to obtain good resolution on phasing and offset timing. Statistical data gathering may be accomplished using a slower poll rate. Sensors that are intelligent, generally provide the ITS center with processed information; thus the amount of information requiring transfer is limited. This is true of traffic controllers and attached detectors, traffic data gathering sensors such as RTMS, AutoTrak™, and WaveTrix™. Video devices generate the most significant amount of data load on an ITS network. This perhaps is understandable since traffic surveillance CCTV provides a significant amount of information to both traffic management and emergence management staff. Real time video is available from CCTV surveillance cameras as well as Video Detection Sensors (VIDS). Resolution of surveillance CCTV video is generally better than video from VIDS since the surveillance camera is designed to support identification while the VIDS focus on detection and detection information extraction. Generally, a quality CCTV surveillance camera is several thousand dollars more expensive than VIDS because of electronics associated with improving the quality and resolution of the video images.

In the modern sense of digital video based on the current National Standards, either MPEG 2 or MPEG 4 video compression is utilized. A separate section of this study is devoted to video compression standards and their differences. Essentially MPEG 2 is designed for broadcast quality, digital video and can accommodate standard digital TV as well as High Definition TV. MPEG 4 grew from Internet multimedia requirements and was merged with H.264 under MPEG 4- Part 10. MPEG 4 part 10 supports both narrow bandwidth as well as wide bandwidth (HDTV) multimedia communications requirements and is the standard that seems to meet ITS requirements for traveler communications over internet as well as digital cellular telephones and may evolve into the cable television standard. Currently MPEG 2, which is invoked by the Advanced Television Standards Committee (ATSC) and is designated by FCC and the US Congress to be the National Standard for broadcast television, is the preferred standard by both satellite and cable television. Because of the cost of deploying surveillance CCTV and the need for quality imaging by law enforcement, most jurisdictions operate MPEG 2 at 6 Mbps. MPEG 4 provides an equivalent image quality at 3 Mbps. Two Mbps is considered adequate for video from VIDS.

With multiple CCTVs deployed and configured to support IP-video stream communications, only that digital video desired by staff for viewing is placed on the network. Using multicast associated with an IP network, only the destination address of multicast users are required to be appended to the digital video packets, as compared to multiple copies of the video stream that would be required by non-IP network communications. There are significant advantages to utilizing a packetized, IP-Video network, including improved efficiency of video stream data transfer and the ability to address the video to specific destinations requesting the video. While an ATM network provides similar functions, it is designed utilizing 53-byte cells as compared to Ethernet's variable length packets. The 53-byte cells were developed to support digital voice communications and are much less efficient in communicating the much longer bit streams associated with digital video. A secondary analysis will be utilized to determine average and peak loading associated with multimedia.

Table 4.0-1 summarizes planning data rates associated with ITS device deployment.

Table 4.0-1: Data Rates for Deployed ITS Devices

ITS Device	Data Rate (Megabits per Second) Field to Center	Data Rate (Bits per Second) Center to Field
Traffic Signal Controller	0.002,048 *	Poll plus periodic maintenance and downloads; 0.0001 Mbps
CCTV Digital IP-Video Stream	3.0 **	N/A
CCTV PTZ/Camera Control	Periodic and Insignificant Status and Alarm	Maintenance and Set Up Commands (Periodic and low data rate)
Video Detection Sensor (VIDS) – Data Only	0.002 (if not part of the traffic signal communications)	Maintenance and Set Up Commands (Periodic and low data rate); 0.0001 Mbps with 1/sec. poll.
VIDS Digital Video Stream (IP-Video)	2.0	Maintenance and Set Up Commands for Video Codec (Periodic and low data rate)
DMS	Periodic Up-load of Messages and Status (0.1 Mbps for 1 sec)	Periodic Down-load of Messages and Commanded Selection; (0.1 Mbps for 1 sec)
Non-VIDS Traffic Sensor	0.002	
Environmental Sensor (No CCTV)	Periodic (0.004 for 1 second upon sensor detection of change)	Maintenance and set up. Periodic and low data rate)
Speed Enforcement	Function of Violations; 1 mbit/violation with video enforcement. With statistics and 100 violations per day, data rate is 0.002.	Maintenance and set up. Periodic and low data rate)
Red Light Enforcement	Same as Speed Enforcement	Maintenance and set up. Periodic and low data rate)
At-Grade Rail Crossing	Same as traffic controller. CCTV Surveillance Covered under CCTV. Train Tracking sensors with	Poll and maintenance/test. Insignificant data rate. Data rate of 0.0001 Mbps if tracking sensor is utilized.

	1/sec. reporting adds 0.002 Mbps data load/	
HAR	Periodic uploads of stored voice messages for update and editing. Assuming IP-Voice at 12 kbps, a 30 sec. message requires 0.36 Mb; for 200 stored messages, 7.2 Mb will be required. This data would only be transferred during a total update; a single message update would be a fraction of a megabit.	Periodic downloads of updated voice messages. Assuming IP-Voice at 12 kbps, a 30 sec. message requires 0.36 Mb; for 200 stored messages, 7.2 Mb will be required. This data would only be transferred during a total update; a single message update would be a fraction of a megabit.
Security/HAZMAT	1 Mbit if Alarm; Assumes Image. Digital Measurement of alarm parameters only would be 0.005 bits.	Maintenance and set up plus periodic poll to verify operations. Insignificant data load.
Probe Vehicle of Opportunity	License Plate Reader 0.1 Mbps (1 Mbps JPEG every 10 sec plus 0.0082 Mbps data)	Maintenance and set up plus periodic poll to verify operations. Insignificant data load.
Other Traffic Sensors	0.00248 Mbps assuming 1/sec poll	Maintenance and set up plus poll; data rate of 0.0001 Mbps with 1/sec poll.

Notes: * Assumes Central Master, 1/sec. Poll and data collection sensors
** Assumes MPEG 4 at 3 Mbps (Double for MPEG 2)

5.0 ITS Network Data Load Projections:

ITS devices interconnected to the supporting communications network require bi-directional communications. Communications networks are designed as simplex, half-duplex and full duplex. Simplex is defined as one-way communications. Half-duplex communications means that communications can occur one way and then the other but not both ways simultaneously. Full duplex means that communications can occur in both directions simultaneously. Polled networks can be half duplex and most of the older, copper twisted pair ITS networks were designed as half duplex. Most modern networks are full duplex allowing the flexibility of the central computer to communicate with any device anytime while still receiving field information. The old analog CCTV video networks were simplex, allowing only video to be sent from the field to the center. A separate, EIA 232, half-duplex communications link was utilized to control the camera's PTZ and other functions. With modern network technology, camera control and digital video reside on the same communications link (not separate circuits).

As previously discussed, many ITS devices have insignificant communications bandwidth requirements. For DMS and HAR, once traveler messages are downloaded from the center to the field device, only message selection command is necessary. Periodic status messaging is utilized to verify that the field device is operational. Thus, this data loading is insignificant over a 24-hour period. Similarly, other sensors just report upon detection of an event or when a sensor measurement reaches a reporting threshold. A flood detection sensor or a gas detection sensor in a tunnel is a good example. These will be considered in determining peak load bandwidth. Peak load bandwidth can be accommodated in several ways. One is that the total bandwidth of the network can accommodate peak load. Another approach is to place priority on communications, where during peak load conditions; specific information has priority use of the network. This is similar to the recent FCC ruling on Cellular telephones that has evolved out of 9/11 Crisis; emergency personnel must have priority use of the cellular service. Since bandwidth is reasonably cheap if initially implemented, it is recommended that a network initially be designed to accommodate peak load. If unforeseen communications growth consumes more bandwidth than was originally planned, than communications can be *throttled back* (especially during an emergency that will require significant communications for coordination and management) using priority. In fact, Quality of Service on both an ATM, or Ethernet Network is based on the designated priority of the communications packets/cells, and thus the network is configurable to accommodate a priority approach to communications.

Utilizing projected ITS deployment for the designated planning periods and data rates presented for ITS devices, **tables 5.0-1** through **5.0-6** were created.

Table 5.0-1: 2007 Projected Data Rates for Jurisdictional ITS Communications

Data Rate Field to Center in Megabits / Second Based on Actual Model												
2007												
City / Town	Traffic Signals	CCTV	VIDS	DMS	Non VID Traffic Sensor	ESS	Speed Enforcement	Rail	Red Light Enforcement	HAR	Security / HAZMAT	TOTAL MBPS
Apache Junction	0.064	24	20.02	-	0.002	-	-	-	-	-	-	44.086
Avondale	0.062	12	18.018	-	0.002	-	-	-	0.004	-	-	30.086
Buckeye	0.048	36	14.014	-	-	-	-	-	-	-	-	50.062
Carefree	0.006		2.002	-	-	-	-	-	-	-	-	2.008
Cave Creek	0.008		2.002	-	-	-	-	-	-	-	-	2.01
Chandler	0.384	117	114.114	-	0.008	-	0.002	0.046	0.002	-	-	231.556
County Areas	0.284	54	86.086	-	0.006	-	-	0.01	0.002	-	-	140.388
El Mirage	0.042	15	12.012	-	-	-	-	-	-	-	-	27.054
Fountain Hills	0.028	12	8.008	-	-	-	-	-	-	-	-	20.036
Gila Bend	0.002	-	-	-	-	-	-	-	-	-	-	0.002
Gila River*	0.004	-	-	-	-	-	-	-	-	-	-	0.004
Gilbert	0.262	12	78.078	-	0.006	-	0.002	0.02	0.002	-	-	90.37
Glendale	0.384	48	116.116	-	0.008	-	0.002	-	0.004	-	-	164.514
Goodyear	0.076	27	22.022	-	0.002	-	-	-	-	-	-	49.1
Guadalupe	0.008		2.002	-	-	-	-	-	-	-	-	2.01
Litchfield Park	0.008		2.002	-	-	-	-	-	-	-	-	2.01
Mesa	0.734	180	208.208	-	0.014	-	0.004	-	0.006	-	-	388.966
Paradise Valley	0.022	6	6.006	-	-	-	-	-	-	-	-	12.028
Peoria*	0.164	3	50.05	-	0.004	-	0.002	0.004	0.002	-	-	53.226
Phoenix	1.926	828	578.578	-	0.038	-	0.01	-	0.024	-	-	1408.576
Queen Creek*	0.028	9	8.008	-	-	-	-	-	-	-	-	17.036
Salt River	0.012	3	4.004	-	-	-	-	-	-	-	-	7.016
Scottsdale	0.566	240	170.17	-	0.008	-	0.001	-	0.028	-	-	410.773
Surprise	0.15	54	46.046	-	0.004	-	-	-	0.002	-	-	100.202
Tempe	0.388	81	116.116	-	0.006	-	0.002	-	0.004	-	-	197.516
Tolleson	0.01	3	4.004	-	-	-	-	-	-	-	-	7.014
Wickenburg	0.01	3	4.004	-	-	-	-	-	-	-	-	7.014
Youngtown	0.008		2.002	-	-	-	-	-	-	-	-	2.01

Table 5.0-2: 2010 Projected Data Rates for Jurisdictional ITS Communications

Data Rate Field to Center in Megabits / Second, Based on 2007 Information and Forward Planning Projections												
2010												
City / Town	**Traffic Signals**	**CCTV**	**VIDS**	**DMS**	**Non VID Traffic Sensor**	**ESS**	**Speed Enforcement**	**Rail**	**Red Light Enforcement**	**HAR**	**Security / HAZMAT**	**TOTAL MBPS**
Apache Junction	0.082	30	42.042	-	0.002	-	0	0	0.002	-	-	**72.046**
Avondale	0.126	45	64.064	-	0.002	-	0	0	0.002	-	-	**109.068**
Buckeye	0.09	33	46.046	-	0.002	-	0	0	0.002	-	-	**79.05**
Carefree	0.006	3	4.004	-	0	-	0	0	0	-	-	**7.004**
Cave Creek	0.008	3	4.004	-	0	-	0	0	0	-	-	**7.004**
Chandler	0.4	141	200.2	-	0.008	-	0.002	0.046	0.008	-	-	**341.264**
County Areas	0.144	51	72.072	-	0.004	-	0	0.01	0.004	-	-	**123.09**
El Mirage	0.046	15	24.024	-	0.002	-	0	0	0.002	-	-	**39.028**
Fountain Hills	0.038	15	20.02	-	0.002	-	0	0	0.002	-	-	**35.024**
Gila Bend	0.004	3	2.002	-	0	-	0	0	0	-	-	**5.002**
Gila River*	0.006	3	4.004	-	0	-	0	0	0	-	-	**7.004**
Gilbert	0.312	111	156.156	-	0.006	-	0.002	0.02	0.006	-	-	**267.19**
Glendale	0.446	156	224.224	-	0.008	-	0.002	0	0.008	-	-	**380.242**
Goodyear	0.094	33	48.048	-	0.002	-	0	0	0.002	-	-	**81.052**
Guadalupe	0.008	3	4.004	-	0	-	0	0	0	-	-	**7.004**
Litchfield Park	0.008	3	4.004	-	0	-	0	0	0	-	-	**7.004**
Mesa	0.828	297	414.414	-	0.016	-	0.004	0.002	0.016	-	-	**711.452**
Paradise Valley	0.024	9	12.012	-	0	-	0	0	0	-	-	**21.012**
Peoria*	0.248	87	124.124	-	0.004	-	0.002	0.004	0.004	-	-	**211.138**
Phoenix	2.616	918	1309.308	-	0.052	-	0.014	0.04	0.052	-	-	**2227.466**
Queen Creek*	0.03	9	16.016	-	0	-	0	0	0	-	-	**25.016**
Salt River	0.012	3	6.006	-	0	-	0	0	0	-	-	**9.006**
Scottsdale	0.39	138	196.196	-	0.008	-	0.002	0	0.008	-	-	**334.214**
Surprise	0.178	63	90.09	-	0.004	-	0	0	0.004	-	-	**153.098**
Tempe	0.274	96	138.138	-	0.006	-	0.002	0.018	0.006	-	-	**234.17**
Tolleson	0.01	3	6.006	-	0	-	0	0	0	-	-	**9.006**
Wickenburg	0.012	3	6.006	-	0	-	0	0	0	-	-	**9.006**
Youngtown	0.008	3	4.004	-	0	-	0	0	0	-	-	**7.004**

Table 5.0-3: 2020Projected Data Rates for Jurisdictional ITS Communications

Data Rate Field to Center in Megabits / Second, Based on 2007 Information and Forward Planning Projections

2020

City / Town	Traffic Signals	CCTV	VIDS	DMS	Non VID Traffic Sensor	ESS	Speed Enforcement	Rail	Red Light Enforcement	HAR	Security / HAZMAT	TOTAL MBPS
Apache Junction	0.098	48	58.058	-	0.002	-	0	-	0.002	-	-	**106.062**
Avondale	0.188	93	112.112	-	0.004	-	0.002	-	0.004	-	-	**205.122**
Buckeye	0.236	114	142.142	-	0.004	-	0.002	-	0.004	-	-	**256.152**
Carefree	0.008	3	4.004	-	0	-	0	-	0	-	-	**7.004**
Cave Creek	0.01	6	6.006	-	0	-	0	-	0	-	-	**12.006**
Chandler	0.442	216	266.266	-	0.008	-	0.004	0.046	0.008	-	-	**482.332**
County Areas	0.17	84	102.102	-	0.004	-	0.002	0.01	0.004	-	-	**186.122**
El Mirage	0.048	24	28.028	-	0.002	-	0	-	0.002	-	-	**52.032**
Fountain Hills	0.046	24	28.028	-	0.002	-	0	-	0.002	-	-	**52.032**
Gila Bend	0.01	6	6.006	-	0	-	0	-	0	-	-	**12.006**
Gila River*	0.006	3	4.004	-	0	-	0	-	0	-	-	**7.004**
Gilbert	0.432	210	260.26	-	0.008	-	0.004	0.02	0.008	-	-	**470.3**
Glendale	0.474	231	284.284	-	0.01	-	0.004	0.012	0.01	-	-	**515.32**
Goodyear	0.248	120	148.148	-	0.006	-	0.002	-	0.006	-	-	**268.162**
Guadalupe	0.008	3	4.004	-	0	-	0	-	0	-	-	**7.004**
Litchfield Park	0.022	9	14.014	-	0	-	0	-	0	-	-	**23.014**
Mesa	0.95	465	570.57	-	0.01	-	0.01	0.002	0.01	-	-	**1035.602**
Paradise Valley	0.024	12	14.014	-	0	-	0	-	0	-	-	**26.014**
Peoria*	0.314	156	188.188	-	0.006	-	0.004	0.004	0.006	-	-	**344.208**
Phoenix	3.112	1515	1869.868	-	0.062	-	0.032	0.05	0.062	-	-	**3385.074**
Queen Creek*	0.09	45	54.054	-	0.002	-	0	-	0.002	-	-	**99.058**
Salt River	0.012	6	8.008	-	0	-	0	-	0	-	-	**14.008**
Scottsdale	0.442	216	266.266	-	0.008	-	0.004	-	0.008	-	-	**482.286**
Surprise	0.328	159	196.196	-	0.006	-	0.004	-	0.006	-	-	**355.212**
Tempe	0.292	141	176.176	-	0.006	-	0.004	0.018	0.006	-	-	**317.21**
Tolleson	0.01	6	6.006	-	0	-	0	-	0	-	-	**12.006**
Wickenburg	0.016	9	10.01	-	0	-	0	-	0	-	-	**19.01**
Youngtown	0.01	6	6.006	-	0	-	0	-	0	-	-	**12.006**

Table 5.0-4: 2025 Projected Data Rates for Jurisdictional ITS Communications

Data Rate Field to Center in Megabits / Second, Based on 2007 Information and Forward Planning Projections												
2025												
City / Town	**Traffic Signals**	**CCTV**	**VIDS**	**DMS**	**Non VID Traffic Sensor**	**ESS**	**Speed Enforcement**	**Rail**	**Red Light Enforcement**	**HAR**	**Security / HAZMAT**	**TOTAL MBPS**
Apache Junction	0.118	69	82.082	-	0.002	-	0.002	-	0.002	-	-	**151.088**
Avondale	0.218	129	152.152	-	0.004	-	0.002	-	0.004	-	-	**281.162**
Buckeye	0.424	249	296.296	-	0.008	-	0.004	-	0.008	-	-	**545.316**
Carefree	0.008	3	6.006	-	0	-	0	-	0	-	-	**9.006**
Cave Creek	0.016	9	12.012	-	0	-	0	-	0	-	-	**21.012**
Chandler	0.44	258	308.308	-	0.008	-	0.004	0.046	0.008	-	-	**566.374**
County Areas	0.192	111	134.134	-	0.004	-	0.002	0.01	0.004	-	-	**245.154**
El Mirage	0.05	30	36.036	-	0.002	-	0	-	0.002	-	-	**66.04**
Fountain Hills	0.046	27	32.032	-	0.002	-	0	-	0.002	-	-	**59.036**
Gila Bend	0.02	12	14.014	-	0	-	0	-	0	-	-	**26.014**
Gila River*	0.008	3	6.006	-	0	-	0	-	0	-	-	**9.006**
Gilbert	0.434	255	304.304	-	0.008	-	0.004	0.02	0.008	-	-	**559.344**
Glendale	0.476	279	334.334	-	0.01	-	0.004	0.012	0.01	-	-	**613.37**
Goodyear	0.38	222	266.266	-	0.008	-	0.004	-	0.008	-	-	**488.286**
Guadalupe	0.008	6	6.006	-	0	-	0	-	0	-	-	**12.006**
Litchfield Park	0.022	12	16.016	-	0	-	0	-	0	-	-	**28.016**
Mesa	0.97	567	680.68	-	0.02	-	0.01	0.002	0.02	-	-	**1247.732**
Paradise Valley	0.024	15	16.016	-	0	-	0	-	0	-	-	**31.016**
Peoria*	0.358	210	250.25	-	0.008	-	0.004	0.004	0.008	-	-	**460.274**
Phoenix	3.23	1890	2264.262	-	0.064	-	0.032	0.07	0.064	-	-	**4154.492**
Queen Creek*	0.112	66	78.078	-	0.002	-	0.002	-	0.002	-	-	**144.084**
Salt River	0.012	6	8.008	-	0	-	0	-	0	-	-	**14.008**
Scottsdale	0.446	261	312.312	-	0.008	-	0.004	-	0.008	-	-	**573.332**
Surprise	0.48	282	136.136	-	0.01	-	0.004	-	0.01	-	-	**418.16**
Tempe	0.296	174	208.208	-	0.006	-	0.004	0.018	0.006	-	-	**382.242**
Tolleson	0.01	6	8.008	-	0	-	0	-	0	-	-	**14.008**
Wickenburg	0.022	12	16.016	-	0	-	0	-	0	-	-	**28.016**
Youngtown	0.01	6	8.008	-	0	-	0	-	0	-	-	**14.008**

Table 5.0-5: 2030 Projected Data Rates for Jurisdictional ITS Communications

Data Rate Field to Center in Megabits / Second, Based on 2007 Information and Forward Planning Projections												
2030												
City / Town	Traffic Signals	CCTV	VIDS	DMS	Non VID Traffic Sensor	ESS	Speed Enforcement	Rail	Red Light Enforcement	HAR	Security / HAZMAT	TOTAL MBPS
Apache Junction	0.142	84	114.114	-	0.002	-	0.002	-	0.002	-	-	**198.12**
Avondale	0.248	144	198.198	-	0.006	-	0.002	-	0.006	-	-	**342.212**
Buckeye	0.586	342	468.468	-	0.012	-	0.006	-	0.012	-	-	**810.498**
Carefree	0.008	3	6.006	-	0	-	0	-	0	-	-	**9.006**
Cave Creek	0.02	12	16.016	-	0	-	0	-	0	-	-	**28.016**
Chandler	0.444	261	356.356	-	0.008	-	0.004	0.046	0.008	-	-	**617.422**
County Areas	0.212	123	170.17	-	0.004	-	0.002	0.01	0.004	-	-	**293.19**
El Mirage	0.052	30	42.042	-	0.002	-	0	-	0.002	-	-	**72.046**
Fountain Hills	0.048	27	38.038	-	0.002	-	0	-	0.002	-	-	**65.042**
Gila Bend	0.028	15	22.022	-	0	-	0	-	0	-	-	**37.022**
Gila River*	0.008	6	6.006	-	0	-	0	-	0	-	-	**12.006**
Gilbert	0.448	261	358.358	-	0.01	-	0.004	0.02	0.01	-	-	**619.402**
Glendale	0.48	282	384.384	-	0.01	-	0.004	0.012	0.01	-	-	**666.42**
Goodyear	0.508	297	406.406	-	0.01	-	0.006	-	0.01	-	-	**703.432**
Guadalupe	0.01	6	8.008	-	0	-	0	-	0	-	-	**14.008**
Litchfield Park	0.022	12	18.018	-	0	-	0	-	0	-	-	**30.018**
Mesa	0.996	582	792.0	-	0.02	-	0.01	0.002	0.02	-	-	**1375.048**
Paradise Valley	0.024	15	20.0	-	0	-	0	-	0	-	-	**35.024**
Peoria*	0.39	228	312.312	-	0.008	-	0.004	0.004	0.008	-	-	**540.336**
Phoenix	3.366	1968	2694.692	-	0.068	-	0.034	0.07	0.068	-	-	**4662.932**
Queen Creek*	0.136	78	108.108	-	0.002	-	0.002	-	0.002	-	-	**186.114**
Salt River	0.012	6	10.01	-	0	-	0	-	0	-	-	**16.01**
Scottsdale	0.45	264	360.36	-	0.01	-	0.004	-	0.01	-	-	**624.384**
Surprise	0.608	357	486.486	-	0.012	-	0.006	-	0.012	-	-	**843.516**
Tempe	0.302	177	242.242	-	0.006	-	0.004	0.018	0.006	-	-	**419.276**
Tolleson	0.01	6	8.008	-	0	-	0	-	0	-	-	**14.008**
Wickenburg	0.024	15	20.02	-	0	-	0	-	0	-	-	**35.02**
Youngtown	0.01	6	8.008	-	0	-	0	-	0	-	-	**14.008**

Table 5.0-6: Projected Data Loads for ADOT Phoenix Area Freeway Management System ITS Field Network

ADOT Phoenix Area Freeway Management System ITS Device Deployment Estimates						
(Ref: FHWA 2006 Survey and FHWA weather in Information)						
Phase	**Current Per FHWA 2006 Survey**	**Freeway Expansion 2007-2010**	**Freeway Expansion 2010-2020**	**Freeway Expansion 2020-2025**	**Freeway Expansion 2025-2030**	**Total**
Miles	**87**	**25**	**45**	**21**	**30**	**208**
ITS Device Deployment	**Data Rate (Mbps) for ITS Device Deployment**	**Additional ITS Device Deployment for Period (Mbps)**	**Additional ITS Device Deployment for Period (Mbps)**	**Additional ITS Device Deployment for Period (Mbps)**	**Additional ITS Device Deployment for Period (Mbps)**	**Data Rate (Mbps) for ITS Device Deployment**
Traffic Controllers	0.322	0.414	0.58	0.658	0.77	**0.77**
Traffic Data Collection	0.4	0.516	0.722	0.818	0.958	**0.958**
Ramp Metering	0.264	0.34	0.476	0.54	0.632	**0.632**
Surveillance CCTV (typical 1/mi)	327	420	588	666	780	**780**
VIDS / Traffic Data and Classification	96	124	174	198	232	**232**
Permanent DMS *(insignificant data rate)*	-	-	-	-	-	**-**
HAR *(insignificant data rate)*	-	-	-	-	-	**-**
Security / HAZMAT *(insignificant data rate)*	-	-	-	-	-	**-**
ESS *(insignificant data rate)*	-	-	-	-	-	**-**
Probe Vehicle of Opportunity Sensors	0	0	1	1.5	2	**2**
DSRC VII	0	0	0	1200	2400	**2400**
Speed Enforcement	0	0	0.02	0.04	0.06	**0.06**
TOTALS Mbps (Combined with Previous Period)	**423.986**	**545.27**	**764.798**	**2067.556**	**3416.42**	**3416.42**

Table 5.0-7 presents the summary of projected bandwidth requirements for ITS devices based on the analysis presented above. **Table 5.0-8** provides a summary of bandwidth requirements for planning periods based on 10% for *insignificant data load* devices and 50% for unknowns. The bandwidth requirements represent peak load capability; however, they do not include center-to-center interoperability as well as regional interoperability.

Table 5.0-7: Summary of Analyzed ITS Data Loads for MAG Area Jurisdictions (in Mbps or bits per second X 10^6)

MPA	2007 ITS Network Coms Load	2010 ITS Network Coms Load	2020 ITS Network Coms Load	2025 ITS Network Coms Load	2030 ITS Network Coms Load
Apache Junction	44.086	72.046	106.062	151.088	198.12
Avondale	30.086	109.068	205.122	281.162	342.212
Buckeye	50.062	79.05	256.152	545.316	810.498
Carefree	2.008	7.004	7.004	9.006	9.006
Cave Creek	2.01	7.004	12.006	21.012	28.016
Chandler	231.556	341.264	482.332	566.374	617.422
County Areas	140.388	123.09	186.122	245.154	293.19
El Mirage	27.054	39.028	52.032	66.04	72.046
Fountain Hills	20.036	35.024	52.032	59.036	65.042
Gila Bend	0.002	5.002	12.006	26.014	37.022
Gila River*	0.004	7.004	7.004	9.006	12.006
Gilbert	90.37	267.19	470.3	559.344	619.402
Glendale	164.514	380.242	515.32	613.37	666.42
Goodyear	49.1	81.052	268.162	488.286	703.432
Guadalupe	2.01	7.004	7.004	12.006	14.008
Litchfield Park	2.01	7.004	23.014	28.016	30.018
Mesa	388.966	711.452	1035.602	1247.732	738.208
Paradise Valley	12.028	21.012	26.014	31.016	207.192
Peoria*	53.226	211.138	344.208	460.274	540.336
Phoenix	1408.576	2227.466	3385.074	4154.492	4662.932
Queen Creek*	17.036	25.016	99.058	144.084	186.114
Salt River	7.016	9.006	14.008	14.008	16.01
Scottsdale	410.773	334.214	482.286	573.332	624.384
Surprise	100.202	153.098	355.212	418.16	843.516
Tempe	197.516	234.17	317.21	382.242	419.276
Tolleson	7.014	9.006	12.006	14.008	14.008
Wickenburg	7.014	9.006	19.01	28.016	35.02
Youngtown	2.01	7.004	12.006	14.008	14.008
ADOT FMS	424.0	545.3	764.8	2,067.6	3,416.4

Table 5.0-8: Summary of Analyzed ITS Data Loads for MAG Area Jurisdictions with 60% Contingency (in Mbps or bits per second X 10^6)

MPA	2007 ITS Network Coms Load	2010 ITS Network Coms Load	2020 ITS Network Coms Load	2025 ITS Network Coms Load	2030 ITS Network Coms Load
Apache Junction	70.6	115.4	10.0	242.0	317.0
Avondale	48.2	174.6	328.0	450.0	547.0
Buckeye	80.2	126.5	410.1	873.0	1,297.0
Carefree	3.2	11.2	11.8	14.4	14.4
Cave Creek	3.2	11.2	19.2	33.6	44.8
Chandler	371.2	546.1	771.7	906.2	987.8
County Areas	224.6	197.0	297.6	392.3	469.1
El Mirage	43.4	62.4	83.2	105.6	115.4
Fountain Hills	32.0	56.0	83.2	94.4	104.0
Gila Bend	0.003	8.0	19.2	41.6	59.2
Gila River*	0.006	11.2	11.2	14.4	19.2
Gilbert	144.6	427.5	752.5	894.9	991.0
Glendale	263.2	608.3	824.5	918.4	1,066.2
Goodyear	78.6	129.8	429.1	781.3	1,125.4
Guadalupe	3.2	11.2	11.2	19.2	22.4
Litchfield Park	3.2	11.2	36.8	44.8	48.0
Mesa	622.4	1,138.4	1,657.0	1,996.3	2,200.2
Paradise Valley	19.2	33.6	41.6	49.6	56.0
Peoria*	85.1	337.8	550.7	736.5	864.5
Phoenix	2,253.8	3,564.0	5,416.2	6,647.2	7,460.6
Queen Creek*	27.2	40.0	158.6	230.6	297.8
Salt River	11.2	14.4	22.4	22.4	25.6
Scottsdale	657.3	534.7	771.7	917.3	999.1
Surprise	160.3	245.0	568.3	669.1	1,349.5
Tempe	316.0	374.2	507.2	611.5	670.9
Tolleson	11.2	14.4	19.2	22.4	22.4
Wickenburg	11.2	14.4	30.4	44.8	56.0
Youngtown	3.2	11.2	19.2	44.8	44.8
ADOT FMS	678.4	872.5	1,223.7	3,308.2	5,466.2

The average load on the ITS network will essentially be that associated with the number of video sources on the network. From a jurisdictional standpoint, considering that the TMC, EMC, and EOC are integrated and that fire stations can also have access to video related to an emergency, then it can be expected that typically 8 video channels will be monitored by each TMC client (3 Clients Typical) and 16 video sources will be assigned to the TMC wall display. Assuming each EMC dispatcher will view 4 video sources and one dispatcher is associated with each 30,000 population, then typical video load on the jurisdictional network can be determined. **Table 5.0-9** identifies EMC Dispatcher Clients and **table 5.0-10** identifies the number of video sources viewed by the

EMC. **Table 5.0-11** summarizes estimated video sources typically viewed (if available) within a jurisdiction (no EOC activated). Table 5.0-12 provides the average data rate assuming TMC and EMC are viewing different video sources. Assuming 40% of the video is common viewing by the TMC and EMC, and uses multicasting on the network, then **table 5.0-13** identifies network video sources and **table 5.0-14** provides average data rate. The assumption is also made that any video being viewed by a fire station would be the same as being viewed by the responsible emergency dispatcher; thus, there would be no additional network loading using multicasting.

Table 5.0-9: Estimated Number of Emergency Management Center Dispatching Clients

MPA	EMC Dispatchers 2007	EMC Dispatchers 2010	EMC Dispatchers 2020	EMC Dispatchers 2025	EMC Dispatchers 2030
Apache Junction	1	2	2	3	3
Avondale	2	3	4	5	5
Buckeye	1	2	5	9	13
Carefree	0	0	0	0	0
Cave Creek	0	0	0	0	0
Chandler	8	9	10	10	10
County Areas	3	3	4	4	5
El Mirage	1	1	1	1	1
Fountain Hills	1	1	1	1	1
Gila Bend	0	0	0	0	1
Gila River*	0	0	0	0	0
Gilbert	6	7	9	9	10
Glendale	8	10	10	10	10
Goodyear	2	3	5	8	11
Guadalupe	0	0	0	0	0
Litchfield Park	0	0	0	0	0
Mesa	15	17	21	21	22
Paradise Valley	0	1	1	1	1
Peoria*	5	5	7	8	8
Phoenix	50	57	67	70	73
Queen Creek*	1	1	2	2	3
Salt River	0	0	0	0	0
Scottsdale	8	8	10	10	10
Surprise	3	4	7	10	13
Tempe	6	6	6	6	7
Tolleson	0	0	0	0	0
Wickenburg	0	0	0	0	1
Youngtown	0	0	0	0	0

(Calculated based on 1 Dispatching Client per 30,000 Residence)

Table 5.0-10: Estimated Number of Emergency Management Center Dispatching Client Video Sources Viewed

MPA	EMC Dispatchers 2007	EMC Dispatchers 2010	EMC Dispatchers 2020	EMC Dispatchers 2025	EMC Dispatchers 2030
Apache Junction	4	8	8	12	12
Avondale	4	12	16	20	20
Buckeye	4	8	20	36	52
Carefree	0	0	0	0	0
Cave Creek	0	0	0	0	0
Chandler	32	36	40	40	40
County Areas	12	12	16	16	20
El Mirage	4	4	4	4	4
Fountain Hills	4	4	4	4	4
Gila Bend	0	0	0	0	4
Gila River*	0	0	0	0	0
Gilbert	24	28	36	36	40
Glendale	32	40	40	40	40
Goodyear	8	12	20	32	44
Guadalupe	0	0	0	0	0
Litchfield Park	0	0	0	0	0
Mesa	60	68	84	84	88
Paradise Valley	0	4	4	4	4
Peoria*	20	20	28	32	32
Phoenix	200	228	268	280	292
Queen Creek*	4	4	8	8	12
Salt River	0	0	0	0	0
Scottsdale	32	32	40	40	40
Surprise	12	16	28	40	52
Tempe	24	24	24	24	28
Tolleson	0	0	0	0	0
Wickenburg	0	0	0	0	4
Youngtown	0	0	0	0	0

(Calculated based on 1 Dispatching Client per 30,000 Residence and 4 video sources viewed per Dispatching Client)

Table 5.0-11: Estimated Number of Video Sources Viewed by TMC and EMC Clients

MPA	EMC/TMC Client Video Sources 2007	EMC/TMC Client Video Sources 2010	EMC/TMC Client Video Sources 2020	EMC/TMC Client Video Sources 2025	EMC/TMC Client Video Sources 2030
Apache Junction	44	48	48	52	52
Avondale	44	52	56	100	100
Buckeye	44	48	60	76	92
Carefree	0	0	0	0	0
Cave Creek	0	0	0	0	0
Chandler	72	76	80	80	80
County Areas	52	52	56	56	60
El Mirage	44	44	44	44	44
Fountain Hills	44	44	44	44	44
Gila Bend	0	0	0	0	0
Gila River*	0	0	0	0	0
Gilbert	64	68	76	76	80
Glendale	72	80	80	80	80
Goodyear	48	52	60	72	84
Guadalupe	0	0	0	0	0
Litchfield Park	0	0	0	0	0
Mesa	100	108	124	124	128
Paradise Valley	0	0	0	0	0
Peoria*	60	60	68	72	72
Phoenix	240	268	308	320	332
Queen Creek*	0	0	48	48	52
Salt River	0	0	0	0	0
Scottsdale	72	72	80	80	80
Surprise	52	56	68	80	92
Tempe	64	64	64	64	68
Tolleson	0	0	0	0	0
Wickenburg	0	0	0	0	0
Youngtown	0	0	0	0	0

(Calculated based on 1 Dispatching Client per 30,000 Residence and 4 video sources viewed per Dispatching Client; 3 Clients per TMC Viewing 8 Video Sources and 16 Video Sources on a TMC Management Display; Threshold for a TMC is 20,000 Population)

Table 5.0-12: Estimated Average Communications Load on Jurisdictional ITS Networks Based on Projected Client Viewing of ITS Digital Video (Mbps)

MPA	ITS Network AV Data Load Mbps 2007	ITS Network AV Data Load Mbps 2010	ITS Network AV Data Load Mbps 2020	ITS Network AV Data Load Mbps 2025	ITS Network AV Data Load Mbps 2030
Apache Junction	134	146	146	158	158
Avondale	134	158	170	302	302
Buckeye	134	146	182	230	278
Carefree	0	0	0	0	0
Cave Creek	0	0	0	0	0
Chandler	218	76	242	242	242
County Areas	158	158	170	170	182
El Mirage	134	134	134	134	134
Fountain Hills	134	134	134	134	134
Gila Bend	0	0	0	0	0
Gila River*	0	0	0	0	0
Gilbert	194	206	230	230	242
Glendale	182	242	242	242	242
Goodyear	146	158	182	182	254
Guadalupe	0	0	0	0	0
Litchfield Park	0	0	0	0	0
Mesa	302	326	374	374	386
Paradise Valley	0	0	0	0	0
Peoria*	182	182	206	218	218
Phoenix	722	806	926	962	998
Queen Creek*	0	0	146	146	158
Salt River	0	0	0	0	0
Scottsdale	182	182	242	242	242
Surprise	158	170	206	242	278
Tempe	194	194	194	194	206
Tolleson	0	0	0	0	0
Wickenburg	0	0	0	0	0
Youngtown	0	0	0	0	0

(Calculated based on TMC and EMC Clients plus 2 Mbps to cover other ITS non-multimedia sensors)

Table 5.0-13: Estimated Number of Video Source Stream (packets) on the ITS Network based on TMC and EMC Clients and Assuming 40% common Viewing

MPA	EMC/TMC Client Video Sources 2007	EMC/TMC Client Video Sources 2010	EMC/TMC Client Video Sources 2020	EMC/TMC Client Video Sources 2025	EMC/TMC Client Video Sources 2030
Apache Junction	43	45	45	47	47
Avondale	43	47	50	76	76
Buckeye	43	45	52	62	71
Carefree	0	0	0	0	0
Cave Creek	0	0	0	0	0
Chandler	59	62	64	64	64
County Areas	47	47	50	50	52
El Mirage	43	43	43	43	43
Fountain Hills	43	43	43	43	43
Gila Bend	0	0	0	0	0
Gila River*	0	0	0	0	0
Gilbert	54	57	62	62	64
Glendale	59	64	64	64	64
Goodyear	45	47	52	59	66
Guadalupe	0	0	0	0	0
Litchfield Park	0	0	0	0	0
Mesa	76	81	90	90	93
Paradise Valley	0	0	0	0	0
Peoria*	52	52	57	59	59
Phoenix	216	244	284	296	308
Queen Creek*	0	0	45	45	47
Salt River	0	0	0	0	0
Scottsdale	59	59	64	64	64
Surprise	47	50	57	64	71
Tempe	54	54	54	54	54
Tolleson	0	0	0	0	0
Wickenburg	0	0	0	0	0
Youngtown	0	0	0	0	0

(Calculated based on 1 Dispatching Client per 30,000 Residence and 4 video sources viewed per Dispatching Client; 3 Clients per TMC Viewing 8 Video Sources and 16 Video Sources on a TMC Management Display; Threshold for a TMC is 20,000 Population; 40% of Video has Common Viewing)

Table 5.0-14: Estimated Average Jurisdictional ITS Network Data Load Based on Video Viewing in ITS Centers and 40% Common (Mbps)

MPA	EMC/TMC AV Data Load Based on Video (Mbps) 2007	EMC/TMC AV Data Load Based on Video (Mbps) 2010	EMC/TMC AV Data Load Based on Video (Mbps) 2020	EMC/TMC AV Data Load Based on Video (Mbps) 2025	EMC/TMC AV Data Load Based on Video (Mbps) 2030
Apache Junction	131	137	137	143	143
Avondale	131	143	152	230	230
Buckeye	131	137	158	188	215
Carefree	0	0	0	0	0
Cave Creek	0	0	0	0	0
Chandler	179	188	194	194	194
County Areas	143	143	152	152	158
El Mirage	131	131	131	131	131
Fountain Hills	131	131	131	131	131
Gila Bend	0	0	0	0	0
Gila River*	0	0	0	0	0
Gilbert	164	173	188	188	194
Glendale	179	194	194	194	194
Goodyear	137	143	158	179	200
Guadalupe	0	0	0	0	0
Litchfield Park	0	0	0	0	0
Mesa	230	245	272	272	281
Paradise Valley	0	0	0	0	0
Peoria*	158	158	173	179	179
Phoenix	650	734	854	890	926
Queen Creek*	0	0	137	137	143
Salt River	0	0	0	0	0
Scottsdale	179	179	194	194	194
Surprise	143	152	173	194	215
Tempe	164	164	164	164	164
Tolleson	0	0	0	0	0
Wickenburg	0	0	0	0	0
Youngtown	0	0	0	0	0

(Calculated based on 3 Mbps per video source viewed plus 2 Mbps for other non-multimedia data)

Desktop video conferencing between ITS centers would add additional network data loading. A full duplex, video conferencing link, assuming full duplex operations would require approximately 4 Mbps of video bandwidth and 24 kbps of voice bandwidth. This also assumes reasonable quality, full screen video. With quarter screen windowing, this data rate can be reduced. Assuming three clients per TMC would add another 12.072 Mbps data load on the jurisdictional network

The issue with designing networks for average data load is that they will not meet the needs of a major emergency, especially involving multiple jurisdictions and requiring evacuation. In this case, the responsible Emergency Operations Center would be activated and it would want to have access to all video information related to evacuation routes and areas associated with the emergency (including areas where a plume of hazardous chemicals, biological agents or nuclear fall out is predicted to contaminate). Thus, it would be appropriate to consider peak loading for network deployment planning.

The average data load of the ADOT network, utilizing similar analysis as used on city networks, is more complex because ADOT's freeway network transitions many jurisdictional areas within the MAG region. The regional analysis will address this interoperability. Assuming ADOT's FMC includes 10 client positions with 8 video sources plus wall displays capable of windowing 48 video sources provides a basis for determining average network loading. The average video load (3 Mbps/source) would be (128 X 3) 384 Mbps. Adding 3 Mbps for non-multimedia sensors would provide an average load of 387 Mbps. Assuming AZ DPS interoperability and providing AZ DPS dispatchers with video in support of incident coordination (assume 10 dispatching positions with 4 videos each) and general surveillance (assume 40% common video source viewing) would add an additional network load of ((40 X 0.60) X 3) or 72 Mbps. Thus, a 459 Mbps average data load is appropriate for consideration. Again, during a major emergency involving use of all available freeways for evacuation, an activated EOC and supporting EMCs would most likely want access to most all available freeway surveillance video and congestion status information. Video conferencing between the TMC, DPS and EOC would add additional load 161 Mbps (40 clients communicating full duplex at 4.024 Mbps ea.).

6.0 Regional ITS Interoperability

6.1 General Considerations

There are a number of approaches applicable to developing an ITS regional communications network. One approach is to utilize the ADOT FMS network to link all jurisdictional IT centers. The second approach is to plan, design and deploy a separate network with the sole purpose of linking jurisdictions networks into a common, wide area network. There are several approaches to developing a dedicated regional network. One is to utilize available jurisdictional infrastructure and the second is to deploy new infrastructure. **Figure 6.1-1** illustrates the dedicated ITS Regional Communications Network approach and **figure 6.1-2** illustrates the approach of utilizing the ADOT optical communications network to support regional interoperability.

Figure 6.1-1: Dedicated Regional ITS Communications Network

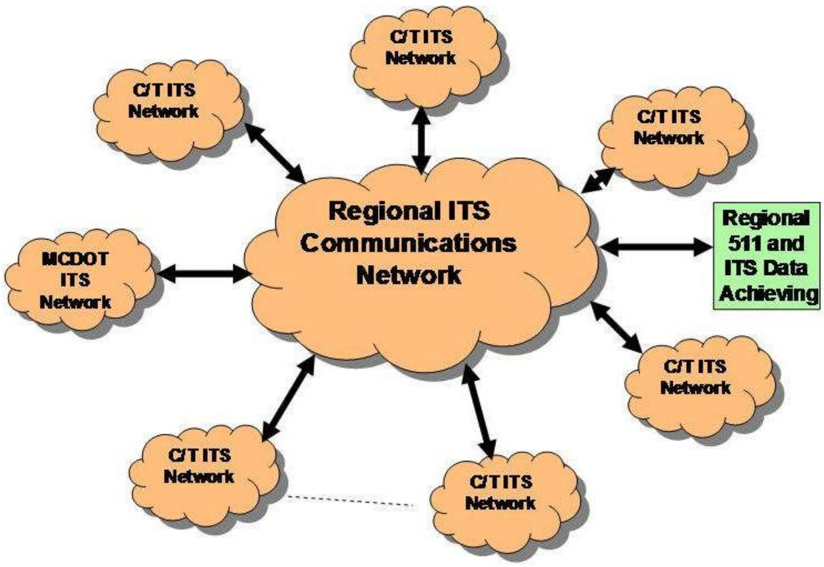
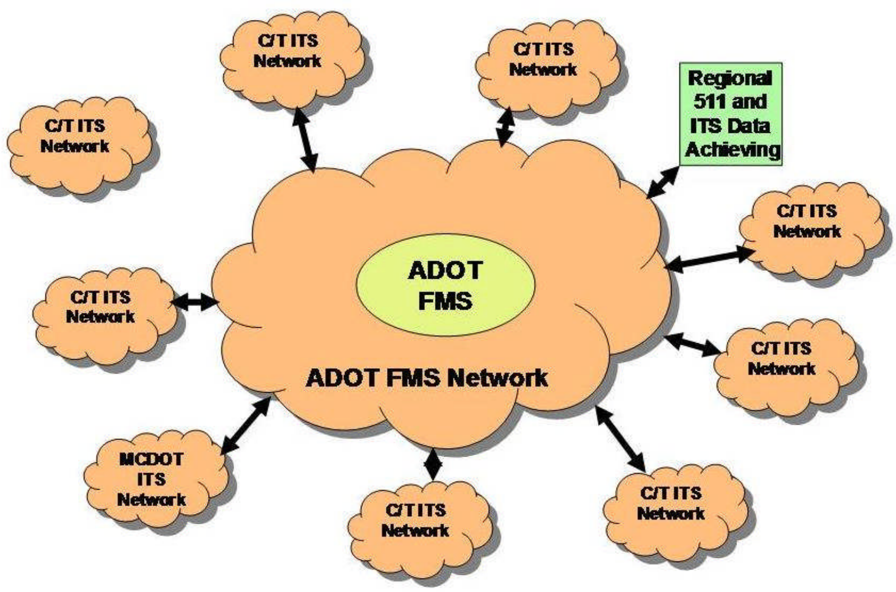


Figure 6.1-2: Regional ITS Network Provided by Bandwidth on the ADOT ITS Network



There are variations of the above architectures based on build out approach and including the possible use of leased infrastructure and communications services during an interim period. From a regional network load perspective, the above architectures are appropriate to consider. **Table 6.1-1** reviews pros and cons of the two architectures.

Table 6.1-1: Pros and Cons of Two ITS Regional Network Approaches

Pro of Dedicated Regional Network	Con of Dedicated Regional Network	Pro of Combined Regional Network	Pro of Combined Regional Network
Simpler to Manage	More Costly	Less Costly	Load Management More Difficult
Simpler to Maintain	Responsibility (Which Jurisdiction?)	Possibly Deployed More Quickly	Establishing Addressing more Difficult
Simpler to Expand as Needed		Management and Maintenance Issues go away	Protocol Management More Difficult
Security Improved			More Difficult to Manage and Control Cyber Security

A dedicated network facilitates management of interface, data load, standards to be utilized, and functional use. For a network integrated with ADOT, all of the basic ADOT Center-to-Field and vise versa communications traffic would be on the network as well as regional interoperability communications. ADOT, because the network supports their basic ITS communications needs, would be the jurisdiction responsible for management, maintenance, configuration control, and access/use control.

6.2 Regional Network Data Load

Regional interoperability includes the sharing of information between jurisdictions related to common corridors of interest, congestion on these corridors, and incidents on these corridors. Basically, the objective of regional interoperability is to manage corridors in such a manner that they the corridor seems seamless to users. This means that signal timing on arterial corridors are coordinated between jurisdictions, messaging to travelers is coordinated, and strategies for congestion, incident, and special event management are coordinated. Most important is responsive and coordinated management of a major incident that requires rapid evacuation form jurisdictions within the region and perhaps even from the complete region. The regional ITS network will provide the linkage between jurisdictional ITS centers. Within the jurisdiction, their jurisdictional ITS network will link their ITS field devices to their centers and link ITS centers within their jurisdiction. This study focuses on the regional communications requirements. Jurisdictional analysis was conducted as related to predicting available information that are candidates to share.

The data load for coordinated traffic signal timing is not significant. The most significant data load on the regional network will be video. Again, video is a key sensor because it provides the ITS managers with real time information on what is happening on the corridors. CCTV images provide information on:

- Congestion
- Incidents
- Road Conditions
- Work Zone and Road Closure Status
- Security of Deployed Infrastructure and ITS Devices
- Verification of DMS Message Display
- General Weather Conditions
- Queues at Entrance Points to corridors and caused by incidents
- Verification of an Incident and Initial Assessment of Seriousness
- Assessment of Damage
- Additional Verification of Traffic Clearance During Land Reversal
- Supports Traveler Security and Safety
- Others

Thus, CCTV is a critical sensor to Traffic and Emergency Management operations. For public transit, they support traveler security at bus stop and transfer points as well as providing bus dispatchers with verification on vehicle location. They also support the security of transit infrastructure. Sharing of jurisdictional video will place the greatest data load on the regional network. Furthermore, travelers desire surveillance video as part of traveler information. Video provides the traveler with confidence that congestion information is indeed correct.

Table 6.2-1 provides a summary of adjacent jurisdictions for cities/towns (exclusive of ADOT) within the MAG region. **Table 6.2-2** summarizes projected, average communications load on a regional ITS network based on coordinated operations between cities/towns. **Figure 6.2-1** illustrates the relationship of ADOT corridors to MAG region city/towns. **Table 6.2-3** summarizes average communications load for ADOOT-Other Jurisdiction interoperability. The summation of **tables 6.2-2 and 6.2-3** represent the average communications load on the regional ITS network of 2.874 Gbps.

Table 6.2-1: Summary of Adjacent Jurisdictions

MPA Jurisdiction	Adjacent Jurisdictions						
Apache Junction	Mesa	County					
Avondale	Phoenix	Litchfield Park	Tolleson	Goodyear			
Buckeye	Goodyear	Surprise	Gila Bend	County			
Carefree	Cave Creek	Phoenix	County				
Cave Creek	Carefree	Phoenix	County				
Chandler	Mesa	Gila River	Tempe				
County Areas	Apache Junction	Buckeye	Carefree, Cave Creek	Gila Bend, Gila River	Goodyear	Salt River	Wicken-burg
El Mirage	Surprise	Peoria	Glendale	Youngtown			
Fountain Hills							
Gila Bend	Buckeye	County					
Gila River	Chandler	Phoenix	County				

Gilbert	Chandler	Queen Creek	Mesa				
Glendale	Phoenix	Youngtown	Peoria	El Mirage			
Goodyear	Avondale	Litchfield Park	Buckeye	County			
Guadalupe	Phoenix	Tempe					
Litchfield Park	Avondale	Goodyear	County				
Mesa	Queen Creek	Apache Junction	Gilbert	Chandler	Tempe	Salt River	
Paradise Valley	Phoenix	Scottsdale					
Peoria	Surprise	Phoenix	Glendale	El Mirage	Young-town		
Phoenix	Scottsdale	Paradise Valley	Tempe, Chandler	Avondale	Tolleson, Carefree	Peoria, Glendale	Cave Creek
Queen Creek*	Gilbert	Mesa	County				
Salt River	Mesa	Scottsdale	Fountain Hills	Tempe	County		
Scottsdale	Phoenix	Carefree	Fountain Hills	Salt River			Paradise Valley
Surprise	Buckeye	Peoria	El Mirage				
Tempe	Chandler	Phoenix	Mesa	Salt River			
Tolleson	Avondale	Phoenix					
Wickenburg	County						
Youngtown	El Mirage	Glendale	Peoria				

Table 6.2-2: Summary of Adjacent Jurisdiction ITS Interoperability Data Load

MPA Jurisdictions	ADOT Corridor Transition Through Region City/Towns Requiring ITS Interoperability	City-to-City Interoperability Data Load on Network (Mbps)	Data Load Based on Criteria of 20,000 Population for TMC Deployment (Mbps)
Apache Junction	2	66	66
Avondale	4	132	132
Buckeye	4	132	132
Carefree	3	99	0
Cave Creek	3	99	0
Chandler	3	99	99
County Areas	9	297	297
El Mirage	4	132	132
Fountain Hills	3	99	99
Gila Bend	2	66	0
Gila River	3	99	0
Gilbert	3	99	99
Glendale	4	132	132
Goodyear	4	132	132
Guadalupe	2	33	0
Litchfield Park	3	99	0
Mesa	6	198	198
Paradise Valley	2	66	0
Peoria	5	165	165
Phoenix	10	330	330
Queen Creek*	3	126	0
Salt River	5	165	0
Scottsdale	5	165	165
Surprise	3	99	99
Tempe	4	132	132

Tolleson	2	66	0
Wickenburg	1	33	0
Youngtown	3	99	0
Total		3,492 Mbps	2,409 Mbps

(Based on Exchange of 8 video images each direction at 3 Mbps each, 4 full duplex video conference channels at 2 Mbps each plus 1 Mbps for voice and other information exchange = 33 Mbps per city/town)

Figure 6.2-1: Jurisdictions in Relation to ADOT Freeways

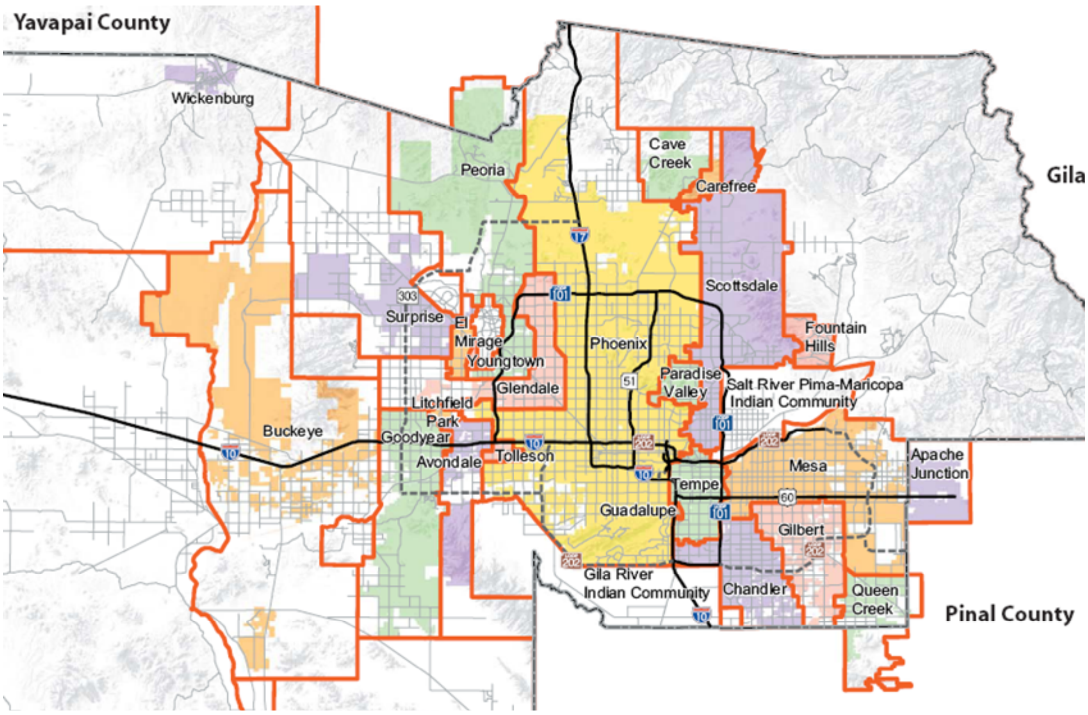


Table 6.2-3: Summary of Adjacent Jurisdiction ITS Interoperability Data Load

MPA Jurisdictions	Adjacent City/Town Potential ITS Interoperability (Current and Planned) Video/data to ADOT (Mbps)	Adjacent City/town Video/data to ADOT (Mbps) Video/data to ADOT (Mbps)	Video/Data to City/Towns from ADOT (Mbps)
Apache Junction	60	15	15
Avondale	Loop 202, I-10	27	27
Buckeye	I-10	15	15
Carefree	-	-	-
Cave Creek	-	-	-
Chandler	Loop 101, Loop 202	27	27
County Areas	I-10, Loop 101, Loop 202, I-17, 303	63	63
El Mirage	-	-	-
Fountain Hills	-	-	-
Gila Bend	Loop 202, I-10	27, (0- No TMC)	0, (No TMC)
Gila River	Loop 202, I-10	27, (0- No TMC)	0, (No TMC
Gilbert	Loop 202, 60	27	27
Glendale	Loop 101	15	15
Goodyear	Loop 202, I-10	27	27
Guadalupe	I-10	15, (0 no TMC)	0, (no TMC)
Litchfield Park	-	-	-
Mesa	Loop 202, 60, Loop 101	39	39
Paradise Valley	-	-	-
Peoria	Loop 101, 303	27	27
Phoenix	I-10, I-17, Loop 101, Loop 202, 51, 60	75	75
Queen Creek	-	-	-
Salt River	Loop 101, Loop 202	27	27
Scottsdale	Loop 101	15	15
Surprise	303	15	15
Tempe	Loop 101, Loop 202, I-10, 60	51	51
Tolleson	I-10	15, (0 no TMC)	0, (no TMC)
Wickenburg	-	-	-
Youngtown	Loop 101	15, (0 no TMC)	0, (no TMC)
Total Data Load on Regional ITS Network (Mbps)		To ADOT(Mbps) 465	From ADOT (Mbps) 465

(Based on Exchange of 4 video images each direction at 3 Mbps each for each ADOT Corridor, 2 full duplex video conference channels at 2 Mbps each plus 1 Mbps for voice and other information exchange = 15 Mbps per city/town for First ADOT Corridor + 12Mbps X Additional ADOT Corridors)

The assumption is made that the information exchange between city/towns will be related to contiguous arterials and communications between cities/towns and

ADOT will be related to arterial corridors, which service the ADOT corridors or provide alternate routes for these corridors. Thus, the assumption is made that only a small percentage will be multicast. Furthermore, the assumption is made that the same information of interest for TMC interoperability will be the same that is of interest to DPS during normal operations. An additional 2 Mbps will be allocated for IEEE 1512 standard communications between DPS and the ADOT FMS (2.876 Gbps total).

The greater data load on the regional ITS network may be the result of providing travelers access to video. There are a number of options, with the heaviest data load occurring when real time video streams are offered to travelers for every video source. By providing a captured video stream (20 to 30 seconds) captured every 4 to 5 minutes reduces the data load. The lightest data load is to provide video frame (JPEG) captured video with a 4-5 minute update, made available to the 511 Traveler Information Center for distribution to requesting users. Distribution would be via internet and cellular service providers. Another consideration must be made if broadcast and cable television news services are going to be provided with real time video access. This provides an additional data load on the network. The data load for providing all interested ATIS and television news stations with video access can essentially represent the equivalent of peak video data load on ADOT and jurisdictional networks. The reason is that providing the public with selected video results in a high probability that someone within the requesting traveler population will seek access to every video source. Thus, the potential data load could be all 2129 surveillance CCTV devices deployed (2030 projection) and all 3718 VIDS video devices deployed (2030 projections) for a peak data load of 6,387 Mbps for CCTV and 7,436 Mbps for VIDS video (total load of 13.823 Gbps. Thus advanced traveler information system (ATIS) video distribution approach must be developed for the region for finalization of data loading.

Last, in a major emergency for the region, Emergency Operations Centers will be activated. These centers will be interested in access to:

- All video sources still operational providing information on status of evacuation routes.
- All video sources available and still operational providing information on the disaster area and areas that may be impacted by pluming.
- Information related to corridor congestion as provided by ITS sensors
- Status of all corridors that may be potential alternates to evacuation routes.
- Weather sensor information available from roadside weather sensors, useful in predicting plum propagation
- Status of public works vehicles that are capable of supporting clearance of debris on corridors
- Status of public transit and school bus resource capable of supporting mass evacuation

- Status of emergency medical facilities planned to support major emergencies
- Status of shelters planned to support evacuees
- Coordinated messaging to travelers as directed by the EOC (to ATIS Centers and DMS at roadside)

This information, if available from jurisdictions will most likely be provided to the activated EOCs via the regional ITS network. Assuming 60% of available video is of interest to the EOC would result in an 8.3 Gbps network data load and assuming 80% is of interest results in an n 11.1 Gbps data load.

6.3 Summary of Regional ITS Network Data Load for Network Planning

Table 6.3-1 summarizes the average and peak data loads for the ITS Regional Communications Network

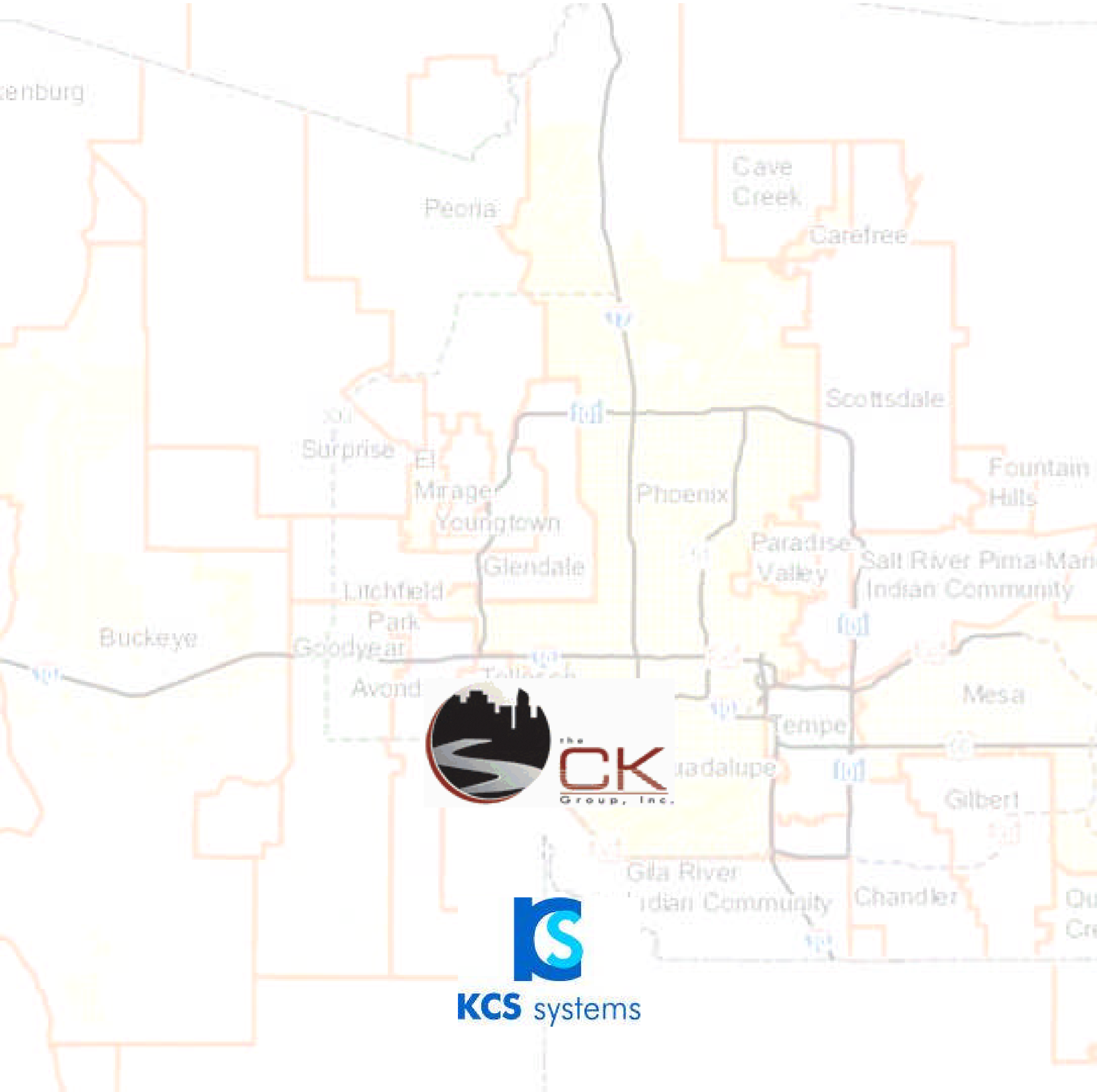
Table 6.3-1: Average and Peak Data Loads on a Regional ITS Network based on 2030 ITS Deployment Projections

Operational Scenario	Average Data Load (Mbps)	Peak Data Load (Mbps)
City/Town/County ITS Information Exchange	2,409	
ADOT to Other Jurisdictions Information Exchange	930	
Emergency with Activated Regional EOC		12,000 (80% Video Access, video conferencing and other emergency related data)
Providing Real Time Video Access for All Video Sources to Public Travelers		14,000 (100% video access and other traffic and accident related information)
	Total Average Data Load = 3,339 Mbps	Peak Load 12,000 to 14,000 Mbps

The average data load on the ADOT ITS network is 459 Mbps. Peak data load is based on a major emergency where all ADOT video is required. This will result in a peak data load of 1,100 Mbps (1.1 Gbps) passed on 2030 ITS deployment projections (550 Mbps based on 2010 projections). To combine Regional communications traffic with ADOT traffic would result in a 14.9 Gbps peak data load not considering multicast. However, it is reasonable to assume that most of the ADOT information would be of interest to an EOC and other jurisdictions; therefore, multicast would reduce the data load to approximately 14.9 Gbps.

The conclusion that can be made from the load analysis is that a regional ITS network will most likely require in excess of 10 gigabits of bandwidth if designed to meet peak load. Peak load will be the results of a major regional emergency and/or allowing public access to real time streaming video without limits. Limiting public access to periodically updated stream segments (20 seconds) and considering only 60%, video source utilization during a major emergency would reduce peak load to approximately 8.5 Gbps.

From this analysis, it is appropriate to consider deployment of a regional ITS network that has 10 Gbps capability but can modularly be upgraded to a higher bandwidth (such as 40 Gbps) utilizing existing fiber. It can further be concluded that wireless solutions will be inadequate to meet data load requirements. It can further be concluded that leased services will be very costly to provide needed bandwidth. DS-3 lease service cost (45 Mbps) is approximately $3000 per month (varies with distance) plus port access cost.



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